MANUAL OF
STRUCTURAL DESIGN

SINGLETON

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MANUAL OF
STRUCTURAL DESIGN

EMPIRE STATE BUILDING

SHREVE, LAMB AND HARMON
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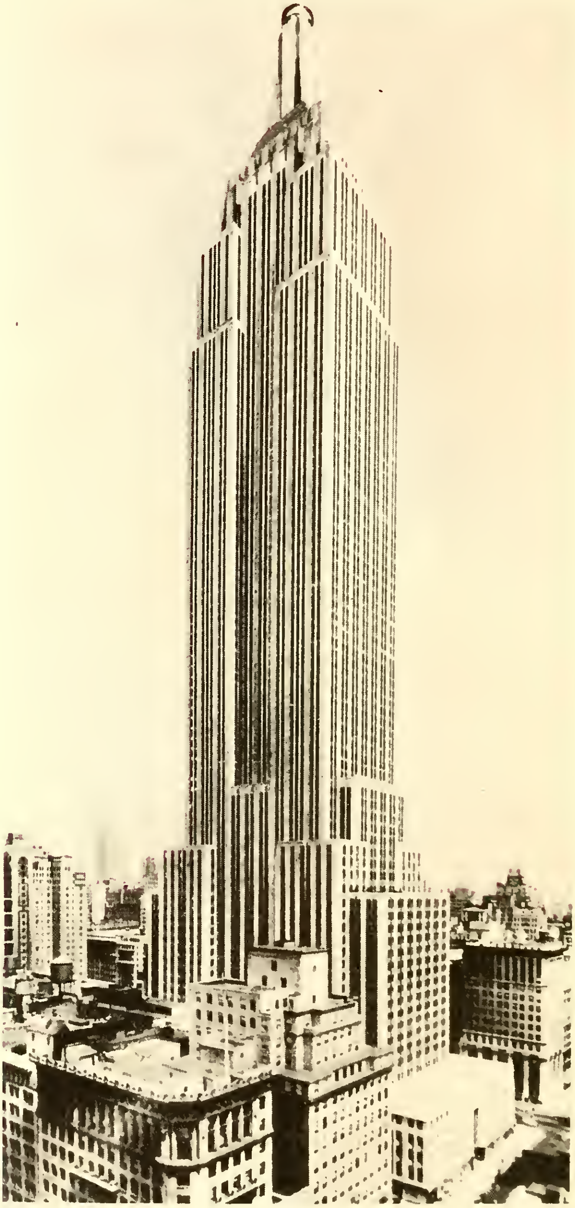
H. G. BALCOM
CONSULTING ENGINEER



DISTINCTIVELY, and distinctly, new; incorporating modern materials and methods in harmony with the most advanced thought of the Era, yet preserving and perpetuating the traditions of correct design and honest workmanship handed down to us from the Past, the American Building is at once an answer and a promise.

● The bold, sweeping dreams of the artist, the sober achievements of engineering science, the efficient solution of myriads of details—the co-relation and co-ordination of all of these with materials best fitted for their several purposes, has given birth to that new form of Architectural Construction so truly American in thought and character.

● Surely, no man contributed more than H. G. Balcom, my friend.

● To him and to the men who have devoted their lives to it in the past, to those who are daily seeking yet better and more efficient design methods, and to the new generations who will take up the burden of preserving the ideals expressed in the towering structures of today, this book is dedicated, by its author.

MANUAL

OF

STRUCTURAL DESIGN

By

JACK SINGLETON

MEMBER, AMERICAN SOCIETY OF CIVIL ENGINEERS
REGISTERED PROFESSIONAL ENGINEER

THIRD EDITION
THIRD PRINTING

PUBLISHED BY
H. M. IVES & SONS, TOPEKA
1952

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by

Jack Singleton

PREFACE TO FIRST EDITION

The theory of structural design has been covered in detail in many excellent textbooks and reference works. A graduate student of engineering should have a good foundation, if he is at all familiar with them.

When engaging in the practice of his profession he finds it necessary, however, to consult many such books, because no one volume contains all the desired information on the subject at hand; the result is much time lost when time is most valuable. Modern structures are generally listed broadly as of structural steel or reinforced concrete, yet in nearly every case both materials are used in the same building. This further complicates matters; the mill handbooks must be referred to on many questions of steel design not covered in textbooks.

Application of the basic theories of design in either material soon proves that short-cuts, mathematically correct yet eliminating excess detail, are not only desirable, but possible. Almost every engineer has some pet chart, or graph, or curve, that he has prepared for simplification of the time-consuming details. Nearly every textbook contains tabulated data of considerable value, yet no one book contains all the desired information on the two basic materials of design.

The "Manual of Structural Design" was prepared for the engineer who earns his livelihood by working at his profession. It begins where most books leave off—the latter set up and explain the basic theory; "Structural Design" accepts that theory as correct, and then applies it in the formulation of data that bears directly on the case in question. The untutored layman cannot use the book; it will prove of very little value to the so-called "handbook engineer" who has but a smattering of knowledge. The book was prepared by an engineer familiar with the actual problems confronting his professional brethren in their daily practice, and with the thought ever in mind of preparing new data, or collating existing information, that will enable an engineer to eliminate much of the drudgery from his daily work.

In the very nature of the thing it is impossible to cover every special case that may arise, nor treat every subject in an entirely original manner. Much of the theory of the profession is even as yet uncrystallized, such as the practical solution of rigid frames, secondary stresses, and indeterminate structures. But with "Structural Design" on his desk, or in his brief-case, the engineer needs no other authority or reference for use in solving ordinary problems.

A majority of the tables herein cover their subjects in an entirely new manner and are truly universal in application. Designing engineers who have used them report that they are extremely pleased with their simplicity, and above all, with the great amount of time saved by their use. Examples are also given of the solution of problems in other phases of design, for ready reference.

One outstanding authority on reinforced concrete construction, namely, "Concrete, Plain and Reinforced", by Taylor, Thompson and Smulski, published by John Wiley & Sons, has been liberally used in the brief practical examples herein. Reference should be made to this work, so justly meriting praise, for a complete resumé of the principles of concrete design.

In spite of careful checking and rechecking, extending over the period of eight years of preparation, errors in this book may exist. We would appreciate having them called to our attention.

Fundamentally, the specifications used as a basis in this book are those of the American Concrete Institute, and the American Institute of Steel Construction, for the two primary materials of construction. Their widespread adoption throughout the country has resulted in a marked increase in efficiency of design.

It is with a great deal of pleasure that appreciation is expressed to Mr. R. A. Finney, Consulting Engineer, who, over a period of years, has aided and assisted in the preparation of the subject matter in this book.

Sincere tribute is paid to Messrs. Taylor, Thompson and Smulski, to Hool and Johnson, Robins Fleming, Milo S. Ketchum and others for their basic works. Personal acknowledgment is also made to the American Institute of Steel Construction, the American Concrete Institute, The American Bridge Company, and personal friends of the Carnegie Steel Company, the Illinois Steel Company, the Jones & Laughlin Steel Company, and the Bethlehem Steel Company.

To those fellow engineers and friends, Dr. D. B. Steinman, H. G. Balcom, Prof. H. A. Rice, F. H. Frankland, and the late Lee H. Miller, who have given of their time and advice, the author expresses deep appreciation and sincere thanks.

J. S.

PREFACE TO SECOND EDITION

The reception accorded the "Manual of Structural Design" has been such as to warrant a second edition; it is hoped that it will receive as favorable consideration as did the initial issue.

Presented as a private venture by a practicing member of the engineering profession, without the assistance or aid of any organization such as is ordinarily considered mandatory in the selling of technical publications, the Manual has literally sold itself. The original edition, with necessary subsequent reprintings having been exhausted, it was felt desirable to take advantage of this fact and make certain changes in the contents, better enabling the book to increase its field of usefulness.

In line with the adoption of new basic unit stresses for structural steel, as sponsored by the American Institute of Steel Construction, new data have been added based upon what is usually called the "Twenty thousand pound stress." However, for the use of those engineers whose work must yet be based upon the 18000 pound specifications, the latter information is also incorporated. It is not within the province of this book to advocate one or the other. Reinforced concrete users are unable, as a body, to agree upon any given combination of allowable stresses; the structural steel designer is given similar latitude herein. Where the specifications of the A. C. I. and the A. I. S. C. govern, the matter is relatively simple; however, there will inevitably be construction projects wherein other matters influence the design standards.

The Manual was developed to meet a particular need—namely, to furnish information on the primary materials of construction in such a manner that the one book would offer information adequate in solving the ordinary problems that confront the designer. Frankly, the writer became rather tired of carrying around with him some six or eight text-books and handbooks; his idea was that all the needed design data could be incorporated between two covers. Since its inception the Manual has been put into active use in some sixty foreign countries, and in all the States of the Union. If it has met with approval—well, we hope that it will continue to merit it.

J. S.

PREFACE TO THIRD EDITION

In the "Preface to First Edition" I gave my reasons for publishing this book. It was not intended to be a textbook; the underlying idea was to provide the designer with tabulated information that would save time and effort. Every engineer has his pet tables and graphs; I used my own in compiling the Manual because I was familiar with them.

When the American Institute of Steel Construction changed its basic stress from 18,000 psi to 20,000 psi, the Second Edition of this Manual was published, containing the new information.

In 1942 I dropped out of the civilian picture, returning to the Corps of Engineers, U. S. A., for a four-year tour of duty. Upon my return to inactive status I found that the entire list of structural steel shapes was being revised, under the aegis of the U. S. Department of Commerce. Too, the AISC was making changes in its specifications. The publication of a Third Edition of Manual of Structural Design, in order to keep it up to date, therefore appeared necessary.

Realizing that some authorities still design structural steel on a basis of 18,000 psi working stress, tabular data is provided for this value, as well as for 20,000 psi. Too, the properties of the old steel sections are given in the rear of the book, since many of the old shapes will "bob up" from time to time.

A great many additional pages have been added which will further increase the usefulness of the book.

I wish to take this means of expressing my deep gratitude to R. A. Finney and to George W. Lamb for the work they have done and the assistance they have given in the preparation of this Third Edition. Too, I wish to acknowledge the cooperation given by Harry Ives, my publisher, in his zeal to keep this Manual truly up to date. He has been that rarest of men—an understanding friend.

Jack Singleton

PART I

REINFORCED CONCRETE DESIGN

MANUAL OF STRUCTURAL DESIGN

STANDARD CONCRETE NOMENCLATURE

With the exception of special cases, so noted, the nomenclature used in this book is as follows:

A = Total area of top of pedestal, pier or footing.
A' = Loaded area of pedestal, pier or footing at column base.
A_c = Area of core of spiral column, measured to outside diameter of spiral.
A_g = Gross area of column with lateral ties.
A_n = Net area of column with lateral ties.
A_s = Effective cross-sectional area tension reinforcement in beams, or compression steel in columns.
A_v = Total area tension web reinforcement within distance "s" (measured perpendicularly to the direction of the web reinforcing) or the total area of all bars bent up in any one plane.
a = Width of top block, both sides, of square footing; or top block, short way, rectangular footing.
b = Width of rectangular beam, or width of flange of tee beam, or width top block, long side, rectangular footing.
b' = Width of stem or web of tee beam.
b_p = Dimension of dropped panel of a flat slab in direction parallel to "l_1".
c = Width of square column, or of narrow side of rectangular column.
c' = Diameter of column capital of a flat slab at the under side of slab or dropped panel.
d = Depth from compression surface of beam, slab or footing to center of longitudinal tension reinforcing.
d' = Depth from compression surface of beam to center of longitudinal compression reinforcing.
e = Width of long side of rectangular column; or eccentricity of beam or column load.
E_c = Modulus of elasticity of concrete in compression.
E_s = Modulus of elasticity of steel in compression or tension = 30,000,000 lbs. sq. in.
f_c = Compressive unit stress in extreme fiber of concrete in flexure, or axial compression in columns.
f'_c = Ultimate compressive strength of concrete at age of 28 days.
f_s = Tensile unit stress in longitudinal reinforcing.
f_v = Tensile unit stress in web reinforcing.
h = Unsupported length of column.
I = Moment of inertia of a section for bending about given axis.
K = Co-efficient, with subscripts as noted.
l = Span of a beam or slab, net or center to center of supports or as otherwise noted.
l = Length, long side, of base of rectangular footing, or of both sides of square footing.
l_1 = Span of flat slab, c. to c. of columns, perpendicular to rectangular direction moments are considered.
M = Bending moment or moment of resistance in general, with subscripts as noted.
M_0 = Sum of positive and negative moments at principal design sections of flat slabs.
n = Ratio of modulii of elasticity of steel and concrete = $E_s \div E_c$.
Σ_0 = Sum of perimeters of bars.
p = Ratio of effective area of tensile reinforcing to effective area of concrete in beams, = $A_s \div bd$.
p = Ratio of effective area of longitudinal reinforcing to area of core in concrete columns.
pa = Permissable unit stress on pedestal, pier or footing, when the full area is loaded.
P = Total safe axial load on column, length not to exceed 11 times least cross sectional dimension.
P' = Total safe axial load on long column.
R = Co-efficient of resistance of beams = $M \div bd^2$.
r = Least radius of gyration, inches.
s = Spacing of stirrups measured perpendicular to direction of stirrup.
s = Length, short side, of base of rectangular footing.
t = Thickness of flange of tee beam.
t_1 = Thickness of flat slab without dropped panels, or thickness of same including dropped panel, where used.
t_2 = Thickness of flat slab with dropped panels at points away from the panel.
u = Bond stress per unit of area of bar surface.
V = Total shear on concrete.
V_s = Shear carried by all steel; excess over that permitted on concrete alone.
v_c = Shearing unit stress carried by concrete alone, value depending on concrete strength and bar anchorage.
v_s = Shearing unit stress carried by stirrups.
v_u = Value of stirrup of given size, for given spacing.
v_x = Change in unit shear per foot.
W = Total dead and live load uniformly distributed over a single panel area (in flat slabs includes the dead weight of any raised or depressed portion).
w = Uniformly distributed load per unit of length of beam or slab; upward reaction on footings per unit of area.
w' = Uniformly distributed dead and live load per unit of area of a floor or roof.
x_1 = Distance from support to point in beam where no stirrups are required.

ALLOWABLE UNIT STRESSES IN CONCRETE

	For Any Strength Concrete	CONCRETE STRENGTH FIXED BY WATER—CEMENT RATIO		
AMERICAN CONCRETE INSTITUTE:	$n = \frac{30000}{f'_c}$	$f'_c = 2000$ $n = 15$	$f'_c = 2500$ $n = 12$	$f'_c = 3000$ $n = 10$
Flexure, f_c.				
Extreme fiber stress in compression	0.40 f'_c	800	1000	1200
Extreme fiber stress in compression, adjacent to supports of continuous or fixed beams	0.45 f'_c	900	1125	1350
Shear, v.				
Beams without web reinforcement and without special anchorage of longitudinal steel	0.02 f'_c	40	50	60
Beams without web reinforcement, but with special anchorage of longitudinal steel	0.03 f'_c	60	75	90
Beams with proper web reinforcement, but without special anchorage of longitudinal steel	0.06 f'_c	120	150	180
Beams with proper web reinforcement, and with special anchorage of longitudinal steel	0.09 f'_c	180	225	270
("Special Anchorage" provides that at least one-third the area of negative steel be anchored beyond point of inflection and at least one-third the area of positive steel be anchored beyond face of support, for continuous or restrained beams; for simple or freely supported beams at least one-half the tensile steel shall extend beyond face of support in tension side of beam. Anchorage to develop one-third the tensile working stress in steel at proper average bond value.)				
Flat slabs, at distance *"d"* from edge of column cap or drop panel	0.03 f'_c	60	75	90
Footings, with no special anchorage of longitudinal bars	0.02 f'_c	40	50	60
With main bars hooked, total length of bar equal to width of footing plus 20 bar diameters. Outer face of hook to be not less than 3″, nor more than 4″, from edge	0.03 f'_c	60	75	90
Bond, u.				
In beams, slabs and one way footings, Plain bars	0.04 f'_c	80	100	120
Deformed bars	0.05 f'_c	100	125	150
In two-way footings, Plain bars	0.03 f'_c	60	75	90
Deformed bars	0.0375 f'_c	75	94	112
(With special anchorage as described above, double these values may be used.)				
Bearing, f_c.				
Where concrete member has an area at least twice the area in bearing	0.25 f'_c	500	625	750
Axial Compression.				
Columns with lateral ties: $P = 0.225 f'_c A_G[1 + (n - 1)p]$	0.225 f'_c	450	563	675
Columns with spiral, circular core: $P = A_c[1 + (n - 1)p]\, f_c$; $f_c = [300 + (0.10 + 4p)f'_c]$				
Ratio of longitudinal reinforcing Spiral not less than one-fourth longitudinal steel area $P = 0.01$	$300 + 0.14 f'_c$	580	650	720
0.02	$300 + 0.18 f'_c$	660	750	840
0.03	$300 + 0.22 f'_c$	740	850	960
0.04	$300 + 0.26 f'_c$	820	950	1080
0.05	$300 + 0.30 f'_c$	900	1050	1200
0.06	$300 + 0.34 f'_c$	980	1150	1320

Tension. Lbs. sq. in. Lbs. sq. in.

Intermediate grade billet steel $f_s = 20000$ Web reinforcement $f_v = 16000$

Rail steel bars $f_s = 20000$ Structural steel shapes $f_s = 18000$

Other steel reinforcement, 50% of yield point stress but not to exceed $f_s = 20000$

Compression.

Bars $= nf_c$ Structural Steel Section in Composite Columns = 15000 Lbs. Sq. In.

Cast Iron Section in Composite Columns = 9000 Lbs. Sq. In.

Shearing Unit Stress $= v = \frac{V}{.875bd}$ Bond Unit Stress $= u = \frac{V}{.875\Sigma_0 d}$

Minimum diameter of primary columns, 12″. Longitudinal reinforcing shall be minimum of $4\text{-}\frac{5}{8}\phi$ bars for tied columns and $6\text{-}\frac{1}{2}\phi$ bars for spiral columns. Effective area of steel not less than 0.005 nor more than 0.02 for tied columns; not less than 0.01 nor more than 0.06 for spiral columns. Pitch of spiral to be not greater than one-sixth the core diameter, nor more than 3″. Ties shall be spaced not more than 12″ cts.

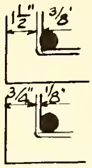
When column length is greater than 50 times the least radius of gyration, "r", of the column core. the permissible working load on core of spiral column, axially loaded, is $\frac{P'}{P} = 1.50 - \frac{h}{100r}$.

For tied columns of length greater than 40r, working load is $\frac{P'}{P} = 1.33 - \frac{h}{120r}$.

Beam

Joist

Edge Distance



REINFORCING BARS

DATA IN ACCORDANCE WITH A. C. I.

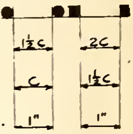
AREAS, WEIGHTS AND PERIMETERS OF BARS

MINIMUM BEAM BAR SPACING

Not Specially Anchored

Specially Anchored

Minimum Spac.



	1	2	3	4	5	SIZE	7	8	9	10	11
	¼φ	⅜φ	½φ	½□	⅝φ	¾φ	⅞φ	1φ	1□	1⅛□	1¼□
AREA—SQ. IN.	0.05	0.11	0.20	0.25	0.31	0.44	0.60	0.79	1.00	1.27	1.56
WEIGHT—LB. PER FT.	0.167	0.376	0.668	0.850	1.043	1.502	2.044	2.670	3.400	4.303	5.313
PERIMETER—INCHES	0.785	1.178	1.571	2.000	1.963	2.356	2.749	3.142	4.000	4.500	5.000

AREAS OF VARIOUS NUMBERS OF BARS

	SIZE	TYPE	WEIGHT ONE BAR	NUMBER OF BARS															
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	¼	φ	0.167	.05	.10	.15	.20	.25	.30	.35	.40	.45	.50	.55	.60	.65	.70	.75	.80
2	⅜	φ	0.376	.11	.22	.33	.44	.55	.66	.77	.88	.99	1.10	1.21	1.32	1.43	1.54	1.65	1.76
3	½	φ	0.668	.20	.40	.60	.80	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	3.00	3.20
4	½	□	0.850	.25	.50	.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00
5	⅝	φ	1.043	.31	.62	.93	1.24	1.55	1.86	2.17	2.48	2.79	3.10	3.41	3.72	4.03	4.34	4.65	4.96
6	¾	φ	1.502	.44	.88	1.32	1.76	2.20	2.64	3.08	3.52	3.96	4.40	4.84	5.28	5.72	6.16	6.60	7.04
7	⅞	φ	2.044	.60	1.20	1.80	2.40	3.00	3.60	4.20	4.80	5.40	6.00	6.60	7.20	7.80	8.40	9.00	9.60
8	1	φ	2.670	.79	1.58	2.37	3.16	3.95	4.74	5.53	6.32	7.11	7.90	8.69	9.48	10.27	11.06	11.85	12.64
9	1	□	3.400	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00
10	1⅛	□	4.303	1.27	2.54	3.81	5.08	6.35	7.62	8.89	10.16	11.43	12.70	13.97	15.24	16.51	17.78	19.05	20.32
11	1¼	□	5.313	1.56	3.12	4.68	6.24	7.80	9.36	10.92	12.48	14.04	15.60	17.16	18.72	20.28	21.84	23.40	24.96

AREA OF STEEL PER FOOT OF WIDTH

SIZE	TYPE	WEIGHT ONE BAR	BAR SPACING															
			3	3½	4	4½	5	5½	6	6½	7	8	9	10	12	14	16	18
¼	φ	0.167	.20	.17	.15	.13	.12	.11	.10	.09	.09	.08	.07	.06				
⅜	φ	0.376	.44	.38	.33	.29	.26	.24	.22	.20	.19	.17	.15	.13				
½	φ	0.668	.80	.69	.60	.53	.48	.44	.40	.37	.34	.30	.27	.24	.20	.17	.15	.13
½	□	0.850	1.00	.86	.75	.67	.60	.55	.50	.46	.43	.38	.33	.30	.25	.21	.19	.17
⅝	φ	1.043	1.24	1.06	.93	.83	.74	.68	.62	.57	.53	.47	.41	.37	.31	.27	.23	.21
¾	φ	1.502	1.76	1.51	1.32	1.17	1.06	.96	.88	.81	.75	.66	.59	.53	.44	.38	.33	.29
⅞	φ	2.044	2.40	2.06	1.80	1.60	1.44	1.31	1.20	1.11	1.03	.90	.80	.72	.60	.51	.45	.40
1	φ	2.670	3.16	2.71	2.37	2.11	1.90	1.72	1.58	1.46	1.35	1.19	1.05	.95	.79	.68	.59	.53
1	□	3.400	4.00	3.43	3.00	2.67	2.40	2.18	2.00	1.85	1.71	1.50	1.33	1.20	1.00	.86	.75	.67
1⅛	□	4.303		4.36	3.81	3.39	3.05	2.77	2.54	2.35	2.18	1.91	1.69	1.52	1.27	1.09	.95	.85
1¼	□	5.313			4.68	4.16	3.74	3.40	3.12	2.88	2.67	2.34	2.08	1.87	1.56	1.34	1.17	1.04

MINIMUM BEAM WIDTHS
BARS NOT SPECIALLY ANCHORED

		NUMBER OF BARS IN ONE LAYER									
		1	2	3	4	5	6	7	8	9	10
¼	φ	4.0	5.3								
⅜	φ	4.1	5.5	6.9	8.3						
½	φ	4.3	5.8	7.3	8.8	10.3	11.8				
½	□	4.3	5.8	7.3	8.8	10.3	11.8	12.3	13.8		
⅝	φ	4.4	6.0	7.6	9.3	10.9	12.5	14.1	15.8	17.4	19.0
¾	φ	4.5	6.4	8.3	10.1	12.0	13.9	15.8	17.6	19.5	21.4
⅞	φ	4.6	6.8	9.0	11.2	13.4	15.6	17.8	20.0	22.1	24.3
1	φ	4.8	7.3	9.8	12.3	14.8	17.3	19.8	22.3	24.8	27.3
1	□	4.8	7.8	10.8	13.8	16.8	19.8	22.8	25.8	28.8	31.8
1⅛	□	4.9	8.3	11.6	15.0	18.4	21.8	25.1	28.5	31.9	35.3
1¼	□	5.0	8.8	12.5	16.3	20.0	23.8	27.5	31.3	35.0	38.8

MINIMUM BEAM WIDTHS
BARS SPECIALLY ANCHORED

		NUMBER OF BARS IN ONE LAYER									
		1	2	3	4	5	6	7	8	9	10
¼	φ	4.0	5.3								
⅜	φ	4.1	5.5	6.9	8.3						
½	φ	4.3	5.8	7.3	8.8	10.3	11.8				
½	□	4.3	5.8	7.3	8.8	10.3	11.8	12.3	13.8		
⅝	φ	4.4	6.0	7.6	9.3	10.9	12.5	14.1	15.8	17.4	19.0
¾	φ	4.5	6.3	8.0	9.8	11.5	13.3	15.0	16.8	18.5	20.3
⅞	φ	4.6	6.5	8.4	10.3	12.1	14.0	15.9	17.8	19.6	21.5
1	φ	4.8	6.8	8.8	10.8	12.8	14.8	16.8	18.8	20.8	22.8
1	□	4.8	7.3	9.8	12.3	14.8	17.3	19.8	22.3	24.8	27.3
1⅛	□	4.9	7.7	10.5	13.3	16.1	19.0	21.8	24.6	27.4	30.2
1¼	□	5.0	8.1	11.3	14.4	17.5	20.6	23.8	26.9	30.0	33.2

REINFORCING BARS

MISCELLANEOUS INFORMATION

2000#   2500   3000

LENGTH BAR REQUIRED TO DEVELOP BOND

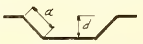
SIZE	TYPE	BOND = 75					BOND = 100					BOND = 125					BOND = 150					BOND = 175					BOND = 200				
		12000	14000	16000	18000	20000	12000	14000	16000	18000	20000	12000	14000	16000	18000	20000	12000	14000	16000	18000	20000	12000	14000	16000	18000	20000	12000	14000	16000	18000	20000
½	ϕ	20	23	27	30	33	15	18	20	23	25	12	14	16	18	20	10	12	13	15	17	9	10	11	13	14	8	9	10	11	13
½	□	20	23	27	30	33	15	18	20	23	25	12	14	16	18	20	10	12	13	15	17	9	10	11	13	14	8	9	10	11	13
⅝	ϕ	25	29	33	37	42	19	22	25	28	31	15	17	20	22	25	13	15	17	19	21	11	12	14	16	18	9	11	13	14	16
¾	ϕ	30	35	40	45	50	22	26	30	34	37	18	21	24	27	30	15	17	20	23	25	13	15	17	19	21	11	13	15	17	19
⅞	ϕ	35	41	47	52	58	26	31	35	39	44	21	24	28	31	35	18	20	23	26	29	15	18	20	22	25	13	15	18	20	22
1	ϕ	40	47	54	60	67	30	35	40	45	50	24	28	32	36	40	20	23	27	30	34	17	20	23	26	29	15	18	20	23	25
1	□	40	47	54	60	67	30	35	40	45	50	24	28	32	36	40	20	23	27	30	34	17	20	23	26	29	15	18	20	23	25
1⅛	□	45	53	60	68	76	34	39	45	51	57	27	32	36	40	45	23	26	30	34	38	19	23	26	29	32	17	20	23	25	28
1¼	□	50	58	67	75	84	38	44	50	56	63	30	35	40	45	50	25	29	33	38	42	21	25	29	32	36	19	22	25	28	31

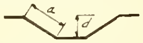
WELDED WIRE MESH

SPACING INCHES		GAGE (W & M)		AREA SQ. IN. PER FOOT		WEIGHT LBS. PER 100 SQ. FT.
LONG.	TRAN.	LONG.	TRAN.	LONG.	TRAN.	
2	16	1	7	.377	.018	140
2	16	2	8	.325	.015	119
2	16	3	8	.280	.015	104
2	16	4	9	.239	.013	89
3	16	2	8	.216	.016	83
2	16	5	10	.202	.011	75
3	16	3	8	.187	.015	72
2	16	6	10	.174	.011	65
3	16	4	9	.159	.013	61
2	16	7	11	.148	.009	55
4	16	3	8	.140	.015	56
3	16	5	10	.135	.011	52
4	16	4	9	.120	.013	48
3	16	6	10	.116	.011	45
4	16	5	10	.101	.011	40
3	16	7	11	.098	.009	38
4	16	6	10	.087	.011	35
3	16	8	12	.082	.007	32
4	16	7	11	.074	.009	30
4	12	8	12	.062	.009	26
4	12	9	12	.052	.009	22
4	12	10	12	.043	.009	19
4	12	12	12	.026	.009	13
4	12	5	5	.101	.034	48
4	12	6	6	.087	.029	42
4	12	7	7	.074	.025	35
4	12	8	8	.062	.021	30

SPACING INCHES		GAGE (W & M)		AREA SQ. IN. PER FOOT		WEIGHT LBS. PER 100 SQ. FT.
LONG.	TRAN.	LONG.	TRAN.	LONG.	TRAN.	
6	12	0	6	.148	.029	65
6	12	2	2	.108	.054	59
6	12	3	3	.093	.047	51
6	12	4	4	.080	.040	44
6	12	5	5	.067	.034	37
6	12	6	6	.058	.029	32
6	12	7	7	.049	.025	27
6	8	12	12	.017	.013	11
6	6	1	1	.126	.126	91
6	6	2	2	.108	.108	78
6	6	3	3	.093	.093	68
6	6	4	4	.080	.080	58
6	6	5	5	.067	.067	49
6	6	6	6	.058	.058	42
6	6	7	7	.049	.049	36
6	6	8	8	.041	.041	30
6	6	9	9	.035	.035	25
6	6	10	10	.029	.029	21
4	4	4	4	.120	.120	85
4	4	6	6	.087	.087	62
4	4	8	8	.062	.062	44
4	4	10	10	.043	.043	31
4	4	12	12	.026	.026	19
4	4	14	14	.015	.015	11
2	2	10	10	.086	.086	60
2	2	12	12	.052	.052	37
2	2	13	13	.039	.039	28
2	2	14	14	.030	.030	21

BAR BENDING DIMENSIONS

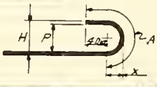




IN INCHES 45°			IN INCHES 30°		
d	a	LENGTH ADDED FOR BENDS	d	a	LENGTH ADDED FOR BENDS
1½	2	1	1½	3	1
2	3	2	2	4	1
2½	3½	2	2½	5	1½
3	4	2	3	6	1½
3½	5	3	3½	7	2
4	5½	3	4	8	2
4½	6½	4	4½	9	2
5	7	4	5	10	2½
5½	8	5	5½	11	3
6	8½	5	6	12	3
8	11½	7	8	16	4
10	14	8	10	20	5
12	17	10	12	24	6
14	20	12	14	28	7
16	23	14	16	32	8
18	26	16	18	36	9
20	28	17	20	40	10
22	31	18	22	44	12
24	34	20	24	48	13
26	37	22	26	52	14
28	40	24	28	56	15
30	42	25	30	60	16
32	45	26	32	64	17
34	48	28	34	68	18
36	51	30	36	72	19
38	54	32	38	76	20
40	57	34	40	80	21
42	59	35	42	84	23
44	62	36	44	88	24
46	65	38	46	92	25
48	68	40	48	96	26
50	71	42	50	100	27
52	74	44	52	104	28
54	76	45	54	108	29
56	79	46	56	112	30
58	82	48	58	116	32
60	86	50	60	120	34

HOOK DIMENSIONS

Method of hooking bars as recommended by A. C. I.



SIZE	AREA	PERIM.	WEIGHT	P	H	X	A
½ ϕ	.20	1.571	.668	2	3	1½	6¾
½ □	.25	2.000	.850	2	3	1½	6¾
⅝ ϕ	.31	1.963	1.043	2½	3¾	1⅞	8½
¾ ϕ	.44	2.356	1.502	3	4½	2¼	10
⅞ ϕ	.60	2.749	2.044	3½	5¼	2⅝	12
1 ϕ	.79	3.142	2.670	4	6	3	1′-1½″
1 □	1.00	4.000	3.400	4	6	3	1′-1½″
1⅛ □	1.27	4.500	4.303	4½	6¾	3⅜	1′-3″
1¼ □	1.56	5.000	5.313	5	7½	3¾	1′-5″

GENERAL SPECIFICATIONS
FOR REINFORCED CONCRETE

AMERICAN CONCRETE INSTITUTE:

Unless designed as long columns as explained before, reinforced concrete columns shall not be longer than eleven times the least lateral dimension.

Where bending exists, bending moments in exterior and interior columns shall be determined for the loading conditions and end restraint encountered.

In flat-slab construction the least column dimension shall not be less than one-fifteenth of the average center to center span, nor less than 16″. For known eccentric loads or unequal column spacing computation of moments shall be made accordingly. Wall columns of flat-slab construction shall be designed to resist a bending moment of $Wl \div 35$. Resistance to the bending moments shall be divided between the columns immediately above and below, in direct proportion to the values of their ratios of $\frac{I}{h}$

Recognized methods shall be followed in calculating stresses due to combined axial load and bending. The section shall not be less than that required for axial load alone. Limiting combined stresses:

1. Columns with spiral reinforcing, $[300 + (0.10 + 4_p) f'_c] + 0.15 f'_c$.
2. Columns with lateral ties, $0.30 f'_c$. Maximum area reinforcing, 4% of total column area.
3. Tension in longitudinal reinforcing due to bending, limited to 16000 lbs. sq. in.

WIND LOADS:

In designing members to resist wind loads, the allowable unit stresses may be increased to 150% of ordinary design values, but the section shall not be less than that required for live and dead load only.

REINFORCING:

The minimum center to center distance between parallel bars shall be 2½ diammeters for round bars or 3 times the side dimension for square bars; if the ends of the bars are anchored as required for shear, the center to center spacing may be reduced to 2 diameters for round bars and 2½ times the side dimension for square bars, but in no case less than 1″ clear distance between bars, nor less than 1⅓ times the maximum size aggregate.

Splices, where permitted, shall provide sufficient lap to transfer the stress between bars by bond and shear. Splices in column bars shall provide a minimum lap of 24 diameters for deformed bars and 30 diameters for plain bars.

Where necessary to use steel in compression in girders, beams or slabs, such steel shall be thoroughly anchored by ties or stirrups, not less than ¼-inch in size, spaced not more than 8″ apart.

Reinforcement for shrinkage and temperature stresses shall be provided where the principal reinforcing extends in one direction only. Such reinforcing shall provide for the following minimum ratios of reinforcement area to concrete area, but in no case shall the bars be placed farther apart than five times the slab thickness, nor more than 18″.

Floor slabs, where plain bars are used	0.0025
Floor slabs, where deformed bars are used	0.0020
Floor slabs, where welded wire fabric is used, max. spacing main wires 12″	0.0018
Roof slabs, where plain bars are used	0.0030
Roof slabs, where deformed bars are used	0.0025
Roof slabs, where welded wire fabric is used, max. spacing main wires 12″	0.0022

SLABS REINFORCED IN TWO DIRECTIONS:

When slabs are supported on all four sides by beams, girders or walls they may be reinforced in both directions, provided the length is not more than one and one-half times the width, in which case the entire load must be carried in the short direction.

In case of square panels, uniformly loaded, one-half the total load may be assumed as resisted by each cross band. In rectangular panels of length L and breadth B, the portion of load assumed as being carried in the short direction, shall be equal to $(\frac{L}{B} - \frac{1}{2})$ times the total load; the remainder to be caried in the long direction. In no case shall the reinforcement be less than that required for shrinkage and temperature.

The moment is less in the portions of the bands adjacent and parallel to the supporting bands. In the quarter width adjacent and parallel to the beams the computed moment may be reduced 50%.

Beams supporting two way slabs shall carry loads as described, considered as uniformly distributed, and no reduction in live load shall be permitted.

TAYLOR, THOMPSON & SMULSKI COLUMN RECOMMENDATIONS.

For columns with lateral ties only, these authors, as do many other authorities and building codes, consider only the effective column area, within fireproofing, in carrying stress. The formula is $P = f_c[A + (n - 1) A_s]$. The steel area, in vertical bars, is limited to 1% minimum and 6% maximum.

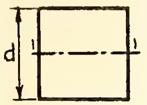
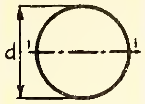
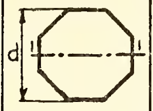
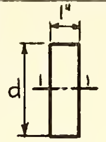
For spiral columns these authors recommend: $P = Af_c + (n - 1) f_c A_s$ or when $A_s = pA$, $P = Af_c[1 + (n - 1) p]$. The allowable concrete stress is $0.35 f'_c$, and in steel is nf_c. Spirals are not considered as adding to the strength of the column, but must be not less than 1% of the core area. Vertical bars, 1% minimum, 6% maximum.

I = Moment of Inertia around axis shown in inches^4.

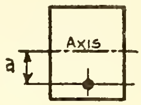
CONCRETE SECTIONS

AREAS, WEIGHTS AND MOMENTS OF INERTIA

Areas, Weights and Moments of Inertia, Various Sections

d												
	AREA SQ. INCH	LBS. PER FOOT	I in.^{4}	AREA SQ. INCH	LBS. PER FOOT	I in.^{4}	AREA SQ. INCH	LBS. PER FOOT	I in.^{4}	AREA SQ. INCH	LBS. PER FOOT	I in.^{4}
6	36	38	108	28	29	64	30	31	71	6.0	6.3	18
7	49	51	203	38	40	118	41	43	132	7.0	7.3	29
8	64	67	344	50	52	201	53	55	224	8.0	8.3	43
9	81	84	549	64	67	322	67	70	360	9.0	9.4	61
10	100	104	830	79	82	491	83	87	548	10.0	10.4	83
11	121	126	1221	95	99	719	100	104	802	11.0	11.5	111
12	144	150	1728	113	118	1018	119	124	1136	12.0	12.5	144
13	169	176	2379	133	138	1402	140	146	1565	13.0	13.5	183
14	196	204	3206	154	160	1886	162	169	2105	14.0	14.6	229
15	225	235	4215	177	184	2485	186	194	2775	15.0	15.6	281
16	256	267	5456	201	210	3217	212	221	3591	16.0	16.7	341
17	289	301	6953	227	237	4100	239	249	4577	17.0	17.7	409
18	324	338	8748	255	265	5153	268	280	5753	18.0	18.8	486
19	361	376	10868	284	295	6397	299	312	7142	19.0	19.8	572
20	400	417	13333	314	327	7854	331	345	8768	20.0	20.8	667
21	441	459	16212	346	361	9547	365	381	10658	21.0	21.9	772
22	484	504	19514	380	396	11499	401	418	12837	22.0	22.9	887
23	529	551	23322	416	433	13737	438	457	15335	23.0	24.0	1014
24	576	600	27648	452	471	16286	477	497	18181	24.0	25.0	1152
25	625	651	32550	491	511	19175	518	539	21406	25.0	26.1	1302
26	676	704	38090	531	553	22432	560	583	25042	26.0	27.1	1465
27	729	759	44280	573	597	26087	604	629	29123	27.0	28.1	1640
28	784	817	51212	616	642	30172	650	677	33683	28.0	29.2	1829
29	841	876	58928	661	688	34719	697	726	38759	29.0	30.2	2032
30	900	937	67500	707	736	39761	746	777	44388	30.0	31.2	2250
31	961	1001	76973	755	786	45333	796	829	50609	31.0	32.3	2483
32	1024	1067	87392	804	838	51472	848	884	57462	32.0	33.3	2731
33	1089	1134	98835	855	891	58214	902	940	64988	33.0	34.4	2995
34	1156	1204	111350	908	946	65597	958	998	73231	34.0	35.4	3275
35	1225	1276	125055	962	1002	73662	1015	1057	82234	35.0	36.5	3573
36	1296	1350	139680	1018	1060	82448	1074	1118	92043	36.0	37.5	3880
37	1369	1426	156177	1075	1120	91998	1134	1181	102704	37.0	38.5	4221
38	1444	1504	173774	1134	1181	102354	1196	1246	114265	38.0	39.6	4573
39	1521	1585	192777	1195	1244	113561	1260	1313	126777	39.0	40.6	4943
40	1600	1667	213320	1257	1309	125664	1326	1381	140288	40.0	41.7	5333
41	1681	1750	235463	1320	1375	138708	1393	1451	154852	41.0	42.7	5743
42	1764	1838	259308	1385	1443	152744	1462	1523	170521	42.0	43.8	6174
43	1849	1925	284918	1452	1512	167819	1533	1598	187350	43.0	44.8	6626
44	1936	2015	312356	1521	1585	183983	1604	1670	205396	44.0	45.8	7099
45	2025	2110	341730	1590	1657	201287	1678	1748	224714	45.0	46.9	7594
46	2116	2202	373106	1662	1731	219785	1754	1826	245365	46.0	47.9	8111
47	2209	2300	406644	1735	1808	239529	1831	1908	267407	47.0	49.0	8652
48	2304	2400	442368	1810	1885	260574	1909	1988	290901	48.0	50.0	9216
49	2401	2500	480396	1886	1965	282977	1990	2074	315911	49.0	51.1	9804
50	2500	2605	520850	1964	2046	306794	2072	2159	342500	50.0	52.1	10417
51	2601	2710	563754	2043	2130	332083	2156	2245	370733	51.0	53.1	11054
52	2704	2818	609284	2124	2210	358905	2241	2335	400677	52.0	54.2	11717
53	2809	2925	657518	2206	2300	387320	2328	2425	432398	53.0	55.2	12406
54	2916	3038	708588	2290	2385	417390	2417	2518	465967	54.0	56.3	13122
55	3025	3150	762575	2376	2475	449177	2507	2610	501454	55.0	57.3	13865
56	3136	3265	819560	2463	2565	482746	2599	2710	538930	56.0	58.3	14635
57	3249	3385	879681	2552	2660	518162	2693	2805	578469	57.0	59.4	15433
58	3364	3505	943022	2642	2750	555493	2788	2902	620144	58.0	60.4	16259
59	3481	3625	1009785	2734	2850	594805	2885	3005	664031	59.0	61.5	17115
60	3600	3750	1080000	2827	2945	636168	2984	3110	710208	60.0	62.5	18000

Moments of Inertia of Bars



ARM	SIZE OF BARS								
a	½ø	½□	⅝ø	¾ø	⅞ø	1ø	1□	1⅛□	1¼□
1							1	1	2
1½				1	1	2	2	3	4
2	1	1	1	2	2	3	4	5	6
2½	1	2	2	3	4	5	6	8	10
3	2	2	3	4	5	7	9	12	14
3½	2	3	4	5	7	10	12	16	19
4	3	4	5	7	10	13	16	20	25
4½	4	5	6	9	12	16	20	26	32
5	5	6	8	11	15	20	25	32	39
5½	6	8	9	13	18	24	30	38	47
6	7	9	11	16	22	28	36	46	56
6½	8	11	13	19	25	33	42	54	66
7	10	12	15	22	29	39	49	62	77
7½	11	14	17	25	34	44	56	71	88
8	13	16	20	28	39	50	64	81	100
8½	14	18	22	32	43	57	72	92	113
9	16	20	25	36	49	64	81	103	127
9½	18	23	28	40	54	71	90	114	141
10	20	25	31	44	60	79	100	127	156
10½	22	28	34	49	66	87	110	149	172
11	24	30	37	53	73	95	121	153	189
11½	26	33	41	58	80	104	132	168	207
12	28	36	44	64	87	113	144	182	225
12½	31	39	48	69	.94	123	156	198	244
13	33	42	52	75	102	133	169	214	264
13½	36	46	56	80	109	144	182	232	284
14	38	49	60	87	118	154	196	248	306
14½	42	53	65	93	126	166	210	267	328
15	44	56	69	99	135	177	225	285	352
15½	48	60	75	106	144	190	240	305	375
16	50	64	79	113	154	201	256	324	400
17	57	72	89	128	174	227	289	366	452
18	64	81	99	143	195	255	324	410	506
19	71	90	111	160	217	284	361	457	564
20	79	100	128	177	241	314	400	506	625
21	87	110	135	195	265	346	441	558	689
22	95	121	148	214	291	380	484	613	756
23	104	132	162	234	318	416	529	670	827
24	113	144	177	254	346	452	576	729	900
25	123	156	192	276	376	491	625	791	977
26	133	169	207	299	407	531	676	856	1056
27	146	182	226	321	438	576	729	926	1137
28	157	196	243	345	471	619	784	996	1223
29	168	210	261	370	504	664	841	1068	1311
30	180	225	279	396	540	711	900	1142	1403
31	192	240	298	423	577	760	961	1220	1500
32	205	256	318	451	615	809	1024	1300	1597
33	218	272	338	479	654	860	1089	1383	1698
34	231	289	359	509	694	914	1156	1468	1804
35	245	306	380	539	735	968	1225	1556	1911
36	259	324	402	570	778	1024	1296	1646	2021
37	274	342	425	603	822	1081	1369	1739	2136
38	289	361	448	636	867	1141	1444	1834	2252
39	304	380	472	670	913	1202	1521	1932	2373
40	320	400	496	704	960	1263	1600	2032	2496

EXPLANATION OF UNIVERSAL BEAM TABLES

The design of reinforced concrete beams is greatly simplified by the use of the Universal Beam Tables. Slabs, Rectangular Beams with balanced reinforcing or with either steel or concrete fiber stress governing, Tee Beams and compression reinforcement for Rectangular or Tee Beams are covered in detail, for any desired combination of fiber stresses in concrete and steel, and for various strengths of concrete. The designer needs but to select the stresses he desires to use, and can then find all types of beams for the given stresses on one page, thus eliminating all lost motion when the design problem changes from Tee to Rectangular Beam, or *vice versa*, or to compression reinforcement for either type.

Three strengths of concrete are used, namely 2,000 lb., 2,500 lb., and 3,000 lb. with values of "*n*" of 15, 12, and 10, respectively. Three values of design unit stresses are also given for each concrete strength, namely, 0.35, 0.40, and 0.45, and for each value mentioned steel stresses of 16,000 18,000 and 20,000 have been incorporated. Almost any combination of stresses is thus provided.

All moments, in kip foot pounds, and steel areas, in square inches, are based on sections one foot or twelve inches, in width, with effective depth as shown, for Rectangular and Tee Beams. Resisting moment values of one square inch of compression steel, placed 2″ from top of beam to center of steel, with required additional area of tensile steel, are given for compression reinforced beams.

The following examples will explain the use of the tables.

SLABS.

Since one-way slabs are simply broad rectangular beams, the tables for the latter are applicable.

1. Assume $M = 3500$ ft. lbs., or 3.5 kips per ft. width; $f_c = 700$; $f_s = 18000$; $n = 15$.
Referring to the table based on unit stresses given, it will be found that
6″ slab, $M = 4.1$ kip ft. lbs. $A_s = 0.52□''$.
The required area of steel for M of 3.5 kips is by direct ratio
$\frac{3.5}{4.1} \times 0.52 = 0.44$ sq. in., requiring ⅝φ bars at 8″ cts.

2. It might be desired for some reason to use a 5″ slab, yet preserving a maximum f_c of 700 #/□″.
5″ slab, $M = 2.8$ kip ft. lbs. $A_s = 0.43□''$.

It is at once noted that the moment value of the slab is much less than that required by actual moment. In order not to exceed the allowable compression in the concrete the neutral axis must be lowered and the area of tensile steel increased, at a lower unit stress. The ratio of M, moment value of balanced design slab, to M_1, the moment to be carried, is $M_1 \div M = 3.5 \div 2.8 = 1.25$. Referring to the table for size limited by concrete stress, the required percentage of steel for this ratio of 1.25 is 206%, and A_s is therefore $2.06 \times 0.43 = 0.89□''$, requiring ¾φ bars @ 6″ cts.

RECTANGULAR BEAMS.

3. Assume $M = 125000$ ft. lbs. or 125.0 kips; $f_c = 700$; $f_s = 18000$; n = 15.
Referring to the proper table it is found that a beam 12″ wide and 34″ eff. depth provides
$M = 130.8$ kips, $A_s = 2.92□''$.
The required area of steel is by direct ratio
$\frac{125.0}{130.8} \times 2.92 = 2.8□''$.

4. Fixed Depth, Any Width.

It may be necessary to maintain a fixed depth of, say 32″ (effective depth 30″) but the beam may be of any width desired. A beam 12″x30″ gives
$M = 101.8$ $A_s = 2.58□''$.

The required width for 30″ eff. depth would be
$\frac{125.0}{101.8} \times 12 = 14.75''$ say 15″, and the required A_s would be
$\frac{125.0}{101.8} \times 2.58 = 3.17□''$.

5. Fixed Depth and Width.

It may for some reason be necessary to limit the beam size to 12″x30″. As noted above, a beam of this size provides $M = 101.8$, with $A_s = 2.58$, but we must carry a moment of 125.0 kips.

As described for slabs it is necessary to find the ratio of $M_1 \div M$. This is $125 \div 101.8 = 1.227$. By interpolation the table gives 194% A_s as required, or $1.94 \times 2.58 = 5.0□''$ tension steel.

It should be mentioned that when the desired moment exceeds the moment value of the intended beam to any appreciable extent or, in other words, if $M_1 \div M$ is excessive, it will be found to be much more economical to use compression reinforcing. For isolated cases, or where excess moment is relatively small, this method of utilizing minimum size beam section will be found extremely useful.

TEE BEAMS.

The tabulated values of Tee Beams cover only those cases wherein the neutral axis lies below the slab. When the neutral axis lies at the bottom of, or within, the slab, use Rectangular Beam Tables.

The tabulated values disregard the compression in the stem, between the neutral axis and the bottom of the slab, and, except for large deep beams, it is not necessary to consider it. When desired, the Tee Beam and Rectangular Beam Tables may be used in conjunction for exact results, as in Example 8.

Fixed Width of Flange.

6. Assume $M = 125.0$ kips; $f_c = 700$; $f_s = 18000$; $n = 15$; $b = 4'\text{-}0''$; slab $= 3''$ thick.
Moment per ft. width $= 125.0 \div 4 = 31.25$ kips.
From proper table, under column for 3″ slab, a beam 12″ wide by 21″ eff. depth gives. $M = 33.2$ $A_s = 1.13\square''$.
By direct ratio the required area of steel is $\dfrac{125.0}{33.2} \times 1.13 = 4.26\square''$.

Fixed Depth.

7. Same assumptions as above, except effective depth must be 20″, with flange width "*b*" unknown.
From tables, a beam with 20″ eff. depth gives $M = 31.1$ $A_s = 1.11$.
The required area of steel is
$\dfrac{125.0}{31.1} \times 1.11 = 4.46\square''$ and width flange required is $\dfrac{125.0}{31.1} \times 12 = 48\tfrac{1}{4}''$.

8. Compression in Stem Considered.

In the foregoing examples the stem compression was neglected. If taken into account, for assumptions as in Example 7, the procedure will be:
Rectangular beam, size 12″x20″, $M = 45.2$, $A_s = 1.72$.
Total moment $= 125.0$, minus M for Rect. Beam, $= 125.0 - 45.2 = 79.8$; to be furnished by flange.
From table, 12″x20″ Tee Beam, 3″ slab, $M = 31.1$ and $A_s = 1.11$.
Required width tee $= 79.8 \div 31.1 = 2.56$ ft. or $30\tfrac{3}{4}''$.
Required A_s, tee, $= (79.8 \div 31.1) \times 1.11 = 2.85\square''$.
Total required flange width, "b" $= 30\tfrac{3}{4} + 12 = 42\tfrac{3}{4}''$.
Total required area of steel $= 2.85 + 1.72 = 4.57\square''$.

It will be noted that the required flange width is slightly less, and area of steel slightly more, than that found when stem compression was neglected.

The width of stem of a Tee Beam is generally fixed by diagonal shear, or bar spacing requirements.

The flange width of a symmetrical Tee Beam shall not exceed one-fourth the net beam span, and the overhanging width on either side shall not exceed eight times the slab thickness, nor half the clear distance to the next beam. Where beams have slab on one side only, as in spandrels or beams around floor openings, the overhanging flange width shall not exceed one-twelfth the net beam span, nor six times the slab thickness, nor half the clear distance to next beam. See specifications.

COMPRESSION REINFORCING.

Where compression in the concrete is excessive, or when the flanges are removed, or when a rectangular beam is limited in size, producing excessive concrete compression stresses, steel may be added in the upper portion of the beam to take the excess compression. The tensile steel will also be increased to balance the couple. The negative moment stresses at support of a continuous Tee Beam make of it an inverted rectangular beam.

Rectangular Beam With Compression Steel.

9. Assume conditions of Example 3; $M = 125.0$ kips; $f_c = 700$; $f_s = 18000$; $n = 15$; except that beam size is limited to 12″ width by 30″ eff. depth. For this size, table gives $M = 101.8$ $A_s = 2.58$.
The beam with balanced reinforcement provides $M = 101.8$;
leaving $125.0 - 101.8 = 23.2$ kips excess.
Referring to table, for eff. depth of 30″, one square inch of compression steel is good for $M_c = 18.7$ kips and requires 0.45 sq. in. additional tensile steel for each sq. in. compression steel. Required compression steel is
$\dfrac{23.2}{18.7} = 1.24\square''$ and additional tensile steel is $1.24 \times 0.45 = 0.56\square''$.
The total tensile steel is therefore $2.58 + 0.56 = 3.14\square''$, and compression steel is $1.24\square''$, placed 2″ from top.
The procedure for Tee Beams is similar, using the Tee Beam tables instead of Rectangular tables.

DESIGN CO-EFFICIENTS.

The tables of values of R, p, k and j for both Rectangular and Tee Beams, provide data sufficient for the computation of any unusual beam not listed in the beam tables, for any combination of fiber stresses. The value of k is the same for rectangular or tee beams.

M = Bending Moment, Kip ft. lbs. for balanced reinforcing.
M_1 = Moment in excess of M for beam size limited by conc.
M_c = Resist. Mom. Kip ft. lbs of 1□" compression steel
A_T = Sq. in. addn'l tensile steel for each 1□" comp. steel.

UNIVERSAL BEAM TABLES

Rectangular Beams and Slabs with Balanced Reinforcing.
Rectangular Beams, Size Limited by Concrete Stress.
Tee Beams for Varying Slab Thickness.
Beams Reinforced for Compression.

$f_c = 700$
$f_s = 16000$
$n = 15$

$f'_c = 2000$
$f_c = 0.35 f'_c$

MOMENTS IN KIP FOOT POUNDS AND STEEL AREAS PER FOOT WIDTH

EFF. DEPTH	Rectang. Beams		TEE BEAMS FOR SLAB THICKNESSES SHOWN																		COMPRESSION REINF.	
			2"		2½"		3"		3½"		4"		4½"		5"		5½"		6"			
"d"	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M_c	A_T
1	.12	.10																				
½	.27	.16																				
2	.48	.21																				
½	.75	.26																				
3	1.1	.31																				
½	1.5	.36																				
4	1.9	.42																				
½	2.4	.47																				
5	3.0	.52																				
½	3.6	.57																				
6	4.3	.62	4.3	.61																	.52	.10
½	5.1	.68	4.9	.64																	.83	.14
7	5.9	.73	5.5	.67	5.9	.72															1.1	.17
½	6.8	.78	7.7	.70	6.7	.76															1.5	.20
8	7.7	.83	6.9	.72	7.4	.79	7.7	.83													1.8	.23
½	8.7	.88	7.6	.74	8.3	.82	8.7	.87													2.2	.25
9	9.7	.94	8.2	.76	9.1	.85	9.6	.91	9.7	.94											2.5	.27
½	10.9	.99	8.9	.78	9.9	.88	10.6	.95	10.8	.99											2.9	.29
10	12.0	1.04	9.5	.79	10.7	.90	11.5	.98	11.9	1.03											3.2	.30
½	13.3	1.09	10.2	.80	11.6	.92	12.5	1.01	13.0	1.07											3.6	.32
11	14.6	1.14	10.9	.81	12.4	.94	13.4	1.03	14.1	1.10	14.5	1.14									4.0	.33
½	15.9	1.20	11.6	.82	13.3	.96	14.4	1.06	15.3	1.13	15.8	1.18									4.4	.34
12	17.3	1.25	12.3	.83	14.1	.97	15.4	1.08	16.4	1.16	17.0	1.22	17.3	1.24							4.7	.35
½	18.8	1.30	13.0	.84	14.9	.98	16.4	1.10	17.6	1.19	18.3	1.25	18.7	1.29							5.1	.36
13	20.3	1.35	13.6	.85	15.7	.99	17.4	1.12	18.7	1.21	19.6	1.28	20.1	1.33	20.3	1.35					5.5	.37
½	22.0	1.40	14.3	.85	16.6	1.01	18.4	1.14	19.9	1.24	20.8	1.31	21.6	1.37	21.9	1.40					5.9	.38
14	23.6	1.46	15.0	.86	17.4	1.02	19.4	1.15	21.0	1.26	22.2	1.34	23.0	1.40	23.4	1.44	23.6	1.46			6.3	.39
½	25.4	1.51	15.7	.87	18.3	1.03	20.5	1.17	22.2	1.28	23.5	1.37	24.5	1.44	25.0	1.48	25.3	1.51			6.7	.40
15	27.1	1.56	16.4	.87	19.2	1.04	21.5	1.18	23.3	1.30	24.8	1.39	25.9	1.47	26.6	1.52	27.0	1.55			7.0	.41
½	29.0	1.61	17.1	.88	20.1	1.05	22.5	1.19	24.5	1.32	26.1	1.42	27.4	1.50	28.2	1.56	28.7	1.59			7.4	.42
16	30.8	1.66	17.8	.88	20.9	1.05	23.5	1.20	25.7	1.33	27.4	1.44	28.8	1.52	29.8	1.59	30.4	1.63	30.7	1.66	7.8	.42
½	32.8	1.72	18.5	.88	21.8	1.06	24.5	1.21	26.9	1.35	28.8	1.46	30.3	1.55	31.4	1.62	32.2	1.67	32.6	1.71	8.2	.43
17	34.8	1.77	19.1	.89	22.6	1.07	25.5	1.22	28.0	1.36	30.1	1.48	31.7	1.57	33.0	1.65	33.9	1.71	34.5	1.75	8.6	.43
18	39.0	1.87	20.5	.90	24.3	1.08	27.6	1.24	30.4	1.39	32.8	1.51	34.7	1.62	36.2	1.70	37.4	1.77	38.3	1.83	9.4	.44
19	43.5	1.98	21.9	.91	26.0	1.09	29.6	1.26	32.8	1.41	35.4	1.54	37.7	1.66	39.5	1.75	41.0	1.83	42.1	1.89	10.2	.45
20	48.1	2.08	23.3	.92	27.8	1.10	31.7	1.28	35.2	1.43	38.1	1.57	40.7	1.69	42.9	1.80	44.6	1.89	46.0	1.96	11.0	.46
21	53.1	2.18	24.7	.92	29.5	1.11	33.8	1.29	37.6	1.45	40.9	1.60	43.7	1.72	46.2	1.84	48.2	1.93	49.8	2.01	11.8	.47
22	58.3	2.29	26.1	.93	31.2	1.12	35.8	1.30	39.9	1.47	43.6	1.62	46.8	1.75	49.5	1.87	51.9	1.98	53.8	2.07	12.6	.47
23	63.7	2.39	27.5	.93	32.9	1.13	37.9	1.32	42.3	1.48	46.3	1.64	49.8	1.78	52.9	1.90	55.5	2.01	57.8	2.11	13.4	.48
24	69.3	2.50	28.9	.94	34.7	1.14	40.0	1.33	44.8	1.50	49.1	1.66	52.8	1.80	56.2	1.94	59.2	2.05	61.6	2.16	14.2	.48
26	81.4	2.70			38.1	1.15	44.1	1.35	49.6	1.53	54.6	1.69	59.0	1.85	63.0	1.99	66.5	2.12	69.7	2.23	15.8	.49
28	94.4	2.91			41.5	1.16	48.2	1.36	54.4	1.55	60.0	1.72	65.1	1.88	69.8	2.03	74.0	2.17	77.7	2.30	17.4	.50
30	108.3	3.12			45.0	1.17	52.4	1.38	59.2	1.57	65.5	1.75	71.3	1.92	76.6	2.07	81.4	2.22	85.8	2.35	19.0	.51
32	123.3	3.33					56.6	1.39	64.2	1.59	71.1	1.77	77.5	1.94	83.5	2.11	89.0	2.26	93.9	2.40	20.6	.52
34	139.1	3.54					60.7	1.40	69.0	1.60	76.5	1.79	83.6	1.97	90.3	2.14	96.4	2.30	102.1	2.45	22.3	.52
36	156.0	3.74					64.9	1.41	73.8	1.61	82.1	1.81	90.0	1.99	97.2	2.16	104.1	2.33	110.4	2.49	23.9	.53
38	173.8	3.95									87.6	1.82	96.2	2.01	104.1	2.19	111.4	2.36	118.5	2.52	25.5	.53
40	192.6	4.16									93.1	1.83	102.3	2.03	111.1	2.21	119.1	2.39	126.8	2.55	27.1	.54
42	212.3	4.37									98.6	1.84	108.5	2.04	117.8	2.23	126.7	2.41	134.9	2.58	28.7	.54
44	233.0	4.58													124.9	2.25	134.4	2.43	143.3	2.61	30.4	.54
46	254.7	4.78													131.7	2.26	141.9	2.45	151.7	2.63	32.0	.55
48	277.3	4.99													138.8	2.28	149.6	2.47	160.0	2.66	33.6	.55
50	300.9	5.20																	168.3	2.68	35.2	.55
52	325.5	5.41																	176.3	2.70	36.9	.55
54	351.0	5.62																	184.8	2.71	38.5	.56
56	377.5	5.82																			40.1	.56
58	404.9	6.03																			41.8	.56
60	433.3	6.24																			43.4	.56
62	462.7	6.45																			45.0	.57
64	493.0	6.66																			46.6	.57

RECTANG. BEAMS LIMITED BY CONCRETE	
M_1/M	%A_s
1.01	103
1.02	106
1.03	110
1.04	114
1.05	117
1.06	121
1.07	125
1.08	129
1.09	133
1.10	137
1.11	141
1.12	145
1.13	150
1.14	154
1.15	159
1.16	164
1.17	169
1.18	175
1.19	181
1.20	187
1.21	193
1.22	198
1.23	204
1.24	211
1.25	218
1.26	225
1.27	232
1.28	239
1.29	248
1.30	256

M = Bending Moment, Kip ft. lbs. for balanced reinforcing.
M_1 = Moment in excess of M for beam size limited by conc.
M_c = Resist. Mom. Kip ft. lbs. of 1 □″ compression steel
A_T = Sq. in. add'n'l tensile steel for each 1 □″ comp. steel.

UNIVERSAL BEAM TABLES

Rectangular Beams and Slabs with Balanced Reinforcing.
Rectangular Beams, Size Limited by Concrete Stress.
Tee Beams for Varying Slab Thickness.
Beams Reinforced for Compression.

$f_c = 800$
$f_s = 16000$
$n = 15$

$f'_c = 2000$
$f_c = 0.40 f'_c$

MOMENTS IN KIP FOOT POUNDS AND STEEL AREAS PER FOOT WIDTH

EFF. DEPTH	Rectang. Beams		TEE BEAMS FOR SLAB THICKNESSES SHOWN																		COMPRESSION REINF.	
			2″		2½″		3″		3½″		4″		4½″		5″		5½″		6″			
"d"	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M_c	A_T
1	.15	.13																				
½	.33	.19																				
2	.59	.26																				
½	.92	.32																				
3	1.3	.39																				
½	1.8	.45																				
4	2.4	.51																				
½	3.0	.58																				
5	3.7	.64																				
½	4.4	.71																				
6	5.3	.77	5.1	.73	5.3	.77															.83	.16
½	6.2	.83	5.9	.77	6.2	.83															1.2	.20
7	7.2	.90	6.6	.80	7.1	.88	7.2	.90													1.6	.23
½	8.3	.96	7.4	.83	8.0	.92	8.3	.96													2.0	.26
8	9.4	1.03	8.1	.85	8.9	.95	9.3	1.01													2.3	.29
½	10.6	1.09	8.9	.87	9.8	.98	10.4	1.06													2.7	.32
9	11.9	1.16	9.6	.89	10.7	1.01	11.5	1.10	11.8	1.15											3.1	.34
½	13.3	1.22	10.4	.91	11.7	1.04	12.6	1.14	13.1	1.20											3.6	.36
10	14.7	1.29	11.2	.92	12.6	1.06	13.7	1.17	14.3	1.24	14.7	1.28									4.0	.37
½	16.2	1.35	12.0	.94	13.6	1.08	14.8	1.20	15.6	1.28	16.1	1.33									4.4	3.9
11	17.8	1.41	12.7	.95	14.6	1.10	15.9	1.23	16.9	1.32	17.5	1.38	17.8	1.41							4.8	.40
½	19.4	1.48	13.5	.96	15.6	1.12	17.1	1.26	18.2	1.36	19.0	1.43	19.4	1.47							5.3	.42
12	21.2	1.54	14.3	.97	16.5	1.14	18.2	1.28	19.5	1.39	20.4	1.47	20.9	1.52	21.2	1.54					5.7	.43
½	23.0	1.61	15.1	.98	17.5	1.15	19.4	1.30	20.8	1.42	21.9	1.51	22.6	1.57	22.9	1.60					6.2	.44
13	24.8	1.67	15.8	.98	18.4	1.16	20.5	1.32	22.1	1.44	23.3	1.54	24.2	1.61	24.6	1.65	24.8	1.67			6.6	.45
½	26.8	1.74	16.6	.99	19.4	1.18	21.7	1.34	23.5	1.47	24.8	1.57	25.9	1.65	26.4	1.70	26.8	1.73			7.1	.46
14	28.8	1.80	17.4	1.00	20.4	1.19	22.8	1.35	24.8	1.49	26.3	1.60	27.5	1.69	28.2	1.75	28.7	1.79			7.5	.47
½	31.0	1.87	18.2	1.01	21.4	1.20	24.0	1.37	26.1	1.51	27.8	1.63	29.2	1.73	30.1	1.79	30.7	1.84			8.0	.48
15	33.1	1.93	19.0	1.01	22.3	1.21	25.1	1.38	27.4	1.53	29.3	1.65	30.8	1.76	31.9	1.83	32.6	1.89	33.0	1.92	8.4	.48
½	35.4	2.00	19.8	1.02	23.3	1.22	26.3	1.40	28.8	1.55	30.9	1.68	32.5	1.79	33.7	1.87	34.6	1.94	35.1	1.98	8.9	.49
16	37.6	2.06	20.6	1.03	24.3	1.23	27.5	1.41	30.1	1.56	32.4	1.70	34.2	1.81	35.5	1.91	36.6	1.98	37.2	2.03	9.3	.50
½	40.1	2.13	21.4	1.03	25.3	1.24	28.7	1.42	31.5	1.58	33.9	1.72	35.9	1.84	37.4	1.94	38.6	2.02	39.4	2.08	9.8	.51
17	42.5	2.19	22.1	1.03	26.2	1.24	29.8	1.43	32.8	1.60	35.4	1.74	37.5	1.87	39.2	1.97	40.6	2.05	41.5	2.12	10.2	.51
18	47.6	2.31	23.8	1.05	28.2	1.26	32.1	1.45	35.6	1.62	38.5	1.78	41.0	1.91	43.0	2.03	44.6	2.12	45.9	2.20	11.1	.52
19	53.0	2.44	25.3	1.05	30.3	1.27	34.5	1.47	38.3	1.65	41.6	1.81	44.4	1.95	46.8	2.08	48.7	2.19	50.3	2.27	12.0	.53
20	58.8	2.57	26.9	1.06	32.2	1.28	36.8	1.49	41.0	1.67	44.7	1.84	47.9	1.99	50.6	2.13	52.9	2.24	54.7	2.34	12.9	.54
21	64.8	2.70	28.5	1.07	34.1	1.29	39.2	1.50	43.7	1.69	47.8	1.87	51.3	2.03	54.4	2.17	57.0	2.29	59.2	2.40	13.8	.54
22	71.1	2.83	30.1	1.07	36.1	1.30	41.6	1.51	46.5	1.71	50.9	1.89	54.8	2.06	58.2	2.20	61.2	2.34	63.7	2.46	14.7	.55
23	77.7	2.96	31.6	1.08	38.1	1.31	43.9	1.53	49.2	1.73	54.0	1.91	58.3	2.08	62.0	2.24	65.4	2.38	68.2	2.50	15.6	.56
24	84.6	3.09	33.3	1.08	40.1	1.32	46.3	1.54	52.0	1.74	57.1	1.93	61.7	2.11	65.9	2.27	69.6	2.42	72.8	2.55	16.5	.56
26	99.3	3.34			44.0	1.33	51.1	1.56	57.5	1.77	63.4	1.97	68.8	2.16	73.7	2.33	78.1	2.49	82.0	2.63	18.4	.57
28	115.2	3.60			48.0	1.34	55.8	1.57	63.0	1.79	69.7	2.00	75.8	2.19	81.5	2.38	86.6	2.54	91.2	2.70	20.2	.58
30	132.2	3.86			52.0	1.35	60.6	1.59	68.6	1.81	76.0	2.03	82.9	2.23	89.2	2.42	95.2	2.60	100.5	2.76	22.1	.59
32	150.5	4.11					65.4	1.60	74.1	1.83	82.3	2.05	90.0	2.26	97.1	2.45	103.7	2.64	109.7	2.81	23.9	.60
34	169.9	4.37					70.1	1.61	79.7	1.85	88.7	2.07	97.0	2.28	104.9	2.48	112.3	2.68	119.2	2.86	25.8	.60
36	190.4	4.63					74.8	1.62	85.2	1.86	95.1	2.09	104.2	2.31	112.8	2.51	121.0	2.71	128.5	2.90	27.6	.61
38	212.2	4.89									101.4	2.11	111.4	2.33	120.7	2.54	129.5	2.74	137.9	2.94	29.3	.61
40	235.1	5.14									107.7	2.12	118.5	2.35	128.6	2.56	138.2	2.77	147.4	2.97	31.3	.62
42	259.2	5.40									113.9	2.13	125.6	2.36	136.4	2.58	147.0	2.80	156.7	3.00	33.2	.62
44	284.5	5.66													144.5	2.60	155.7	2.82	166.2	3.03	35.0	.63
46	310.9	5.91													152.5	2.62	164.5	2.84	175.7	3.05	36.9	.63
48	338.5	6.17													160.4	2.64	172.9	2.86	185.3	3.08	38.8	.63
50	367.3	6.43																	194.7	3.10	40.6	.63
52	397.3	6.69																	204.1	3.11	42.5	.64
54	428.5	6.94																	213.9	3.14	44.3	.64
56	460.8	7.20																			46.2	.64
58	494.3	7.46																			48.1	.64
60	529.0	7.71																			49.9	.65
62	564.8	7.97																			51.7	.65
64	601.9	8.23																			53.5	.65

RECTANG. BEAMS LIMITED BY CONCRETE	
M_1/M	%A_s
1.01	103
1.02	107
1.03	111
1.04	114
1.05	118
1.06	122
1.07	126
1.08	130
1.09	134
1.10	139
1.11	143
1.12	148
1.13	153
1.14	158
1.15	163
1.16	168
1.17	174
1.18	180
1.19	186
1.20	194
1.21	200
1.22	207
1.23	214
1.24	222
1.25	230
1.26	238
1.27	246
1.28	255
1.29	264
1.30	274

M = Bending Moment, Kip ft. lbs. for balanced reinforcing.
M_1 = Moment in excess of M for beam size limited by conc.
M_c = Resist. Mom. Kip ft. lbs. of 1 □″ compression steel
A_T = Sq. in. addn'l tensile steel for each 1 □″ comp. steel.

UNIVERSAL BEAM TABLES

Rectangular Beams and Slabs with Balanced Reinforcing.
Rectangular Beams, Size Limited by Concrete Stress.
Tee Beams for Varying Slab Thickness.
Beams Reinforced for Compression.

$f_c = 900$
$f_s = 16000$
$n = 15$

$f'_c = 2000$
$f_c = 0.45 f'_c$

MOMENTS IN KIP FOOT POUNDS AND STEEL AREAS PER FOOT WIDTH

EFF. DEPTH	Rectang. Beams		TEE BEAMS FOR SLAB THICKNESSES SHOWN																		COMPRESSION REINF	
			2″		2½″		3″		3½″		4″		4½″		5″		5½″		6″			
"d"	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M_c	A_T
1	.18	.15																				
½	.39	.23																				
2	.70	.31																				
½	1.1	.39																				
3	1.6	.46																				
½	2.1	.54																				
4	2.8	.62																				
½	3.5	.70																				
5	4.4	.77																				
½	5.3	.85																				
6	6.3	.93	5.9	.86	6.2	.92															1.1	.21
½	7.4	1.00	6.8	.90	7.3	.98															1.6	.26
7	8.6	1.08	7.6	.93	8.3	1.03	8.4	1.08													2.0	.30
½	9.8	1.16	8.5	.96	9.3	1.07	9.7	1.14													2.5	.33
8	11.2	1.24	9.3	.98	10.3	1.11	10.9	1.20	11.0	1.23											2.9	.36
½	12.7	1.31	10.2	1.00	11.4	1.15	12.2	1.25	12.5	1.30											3.4	.38
9	14.1	1.39	11.0	1.02	12.4	1.18	13.4	1.29	13.9	1.36											3.8	.40
½	15.8	1.47	11.9	1.04	13.5	1.21	14.7	1.33	15.4	1.41											4.3	.42
10	17.5	1.54	12.8	1.05	14.6	1.23	15.9	1.36	16.8	1.46	17.3	1.52									4.7	.44
½	19.2	1.62	13.7	1.07	15.7	1.25	17.2	1.39	18.3	1.50	18.9	1.58									5.2	.46
11	21.1	1.70	14.6	1.08	16.7	1.27	18.4	1.42	19.7	1.54	20.5	1.63	21.0	1.68							5.7	.47
½	23.1	1.78	15.5	1.09	17.8	1.29	19.7	1.45	21.2	1.58	22.2	1.68	22.8	1.74							6.2	.49
12	25.1	1.85	16.3	1.10	18.9	1.30	21.0	1.47	22.6	1.61	23.8	1.72	24.6	1.79	25.0	1.84					6.7	.50
½	27.3	1.93	17.3	1.12	20.0	1.32	22.3	1.49	24.1	1.64	25.5	1.76	26.4	1.84	27.0	1.90					7.2	.51
13	29.5	2.01	18.2	1.13	21.0	1.33	23.6	1.51	25.6	1.67	27.1	1.79	28.2	1.89	29.0	1.96	29.4	2.00			7.7	.52
½	31.9	2.09	19.0	1.13	22.1	1.35	24.9	1.53	27.1	1.70	28.8	1.83	30.1	1.93	31.0	2.01	31.6	2.06			8.2	.53
14	34.2	2.16	19.8	1.14	23.2	1.36	26.2	1.55	28.5	1.72	30.5	1.86	31.9	1.97	33.0	2.06	33.7	2.12	34.1	2.15	8.7	.54
½	36.8	2.24	20.7	1.14	24.4	1.37	27.5	1.57	30.1	1.74	32.2	1.89	33.8	2.01	35.1	2.11	36.0	2.17	36.5	2.22	9.2	.55
15	39.3	2.32	21.6	1.15	25.5	1.38	28.8	1.58	31.6	1.76	33.9	1.91	35.7	2.04	37.1	2.15	38.2	2.22	38.9	2.28	9.7	.56
½	42.0	2.40	22.5	1.16	26.6	1.39	30.1	1.60	33.1	1.78	35.6	1.94	37.6	2.07	39.2	2.19	40.4	2.27	42.3	2.34	10.2	.57
16	44.7	2.47	23.4	1.17	27.7	1.40	31.4	1.61	34.6	1.80	37.3	1.96	39.5	2.10	41.3	2.22	42.6	2.32	43.6	2.39	10.7	.57
½	47.6	2.55	24.3	1.17	28.8	1.41	32.7	1.62	36.2	1.82	39.0	1.99	41.4	2.13	43.4	2.26	44.9	2.36	46.1	2.44	11.2	.58
17	50.4	2.63	25.1	1.18	29.9	1.42	34.0	1.63	37.7	1.83	40.7	2.01	43.3	2.16	45.5	2.29	47.2	2.40	48.5	2.49	11.7	.59
18	56.5	2.78	27.0	1.19	32.1	1.43	36.7	1.66	40.7	1.86	44.2	2.04	47.2	2.21	49.7	2.35	51.8	2.47	53.5	2.57	12.7	.60
19	63.0	2.93	28.7	1.19	34.3	1.45	39.3	1.68	43.8	1.89	47.7	2.08	51.0	2.25	54.0	2.41	56.4	2.54	58.4	2.65	13.7	.61
20	69.8	3.09	30.5	1.20	36.6	1.46	42.0	1.69	46.8	1.91	51.2	2.11	55.0	2.29	58.3	2.45	61.1	2.60	63.5	2.72	14.8	.62
21	77.0	3.24	32.3	1.21	38.8	1.47	44.7	1.71	49.9	1.93	54.6	2.14	58.9	2.33	62.6	2.50	65.8	2.65	68.5	2.78	15.8	.62
22	84.5	3.40	34.1	1.22	41.0	1.48	47.3	1.72	53.0	1.95	58.2	2.16	62.8	2.36	66.9	2.54	70.5	2.70	73.6	2.84	16.8	.63
23	92.3	3.55	35.8	1.22	43.2	1.49	50.0	1.74	56.1	1.97	61.7	2.19	66.7	2.39	71.2	2.57	75.3	2.74	78.7	2.90	17.9	.64
24	100.5	3.71	37.7	1.23	45.5	1.50	52.6	1.75	59.2	1.98	65.2	2.21	70.7	2.42	75.6	2.61	80.0	2.78	83.9	2.94	18.9	.64
26	118.0	4.02			49.9	1.51	58.0	1.77	65.4	2.02	72.3	2.25	78.6	2.46	84.3	2.66	89.5	2.85	94.3	3.03	21.0	.66
28	136.8	4.32			54.4	1.52	63.3	1.79	71.6	2.04	79.3	2.28	86.5	2.50	93.2	2.72	99.2	2.92	104.6	3.10	23.0	.66
30	157.1	4.63			59.0	1.53	68.7	1.80	77.9	2.06	86.5	2.31	94.4	2.54	101.9	2.76	108.8	2.97	115.1	3.16	25.1	.67
32	178.7	4.94					74.1	1.82	84.2	2.08	93.6	2.33	102.4	2.57	110.7	2.80	118.4	3.01	125.7	3.22	27.2	.68
34	201.7	5.25					79.4	1.83	90.4	2.10	100.8	2.35	110.5	2.60	119.5	2.83	128.1	3.06	136.1	3.27	29.3	.69
36	226.2	5.56					84.8	1.84	96.7	2.11	107.8	2.37	118.4	2.62	128.5	2.86	137.9	3.09	146.8	3.31	31.4	.69
38	252.0	5.87									115.0	2.39	126.5	2.64	137.4	2.89	147.5	3.12	157.3	3.35	33.5	.70
40	279.2	6.18									122.1	2.40	134.5	2.66	146.2	2.91	157.3	3.15	167.8	3.38	35.5	.70
42	307.8	6.49									129.3	2.42	142.5	2.68	155.0	2.93	167.1	3.18	178.5	3.42	37.6	.71
44	337.9	6.80													164.1	2.96	176.9	3.20	189.3	3.45	39.7	.71
46	369.3	7.10													173.0	2.98	186.8	3.23	199.8	3.47	41.8	.71
48	402.1	7.41													181.8	2.99	196.6	3.25	210.5	3.50	43.9	.72
50	436.3	7.72																	221.4	3.52	46.0	.72
52	471.9	8.03																	231.8	3.54	48.1	.72
54	508.9	8.34																	242.6	3.56	50.2	.72
56	547.3	8.65																			52.3	.73
58	587.1	8.96																			54.4	.73
60	628.3	9.27																			56.5	.73
62	670.8	9.58																			58.6	.73
64	714.8	9.88																			60.7	.73

RECTANG. BEAMS LIMITED BY CONCRETE	
M_1/M	%A_s
1.01	103
1.02	107
1.03	111
1.04	114
1.05	118
1.06	122
1.07	126
1.08	130
1.09	135
1.10	140
1.11	145
1.12	151
1.13	157
1.14	163
1.15	169
1.16	175
1.17	182
1.18	189
1.19	196
1.20	203
1.21	210
1.22	217
1.23	225
1.24	234
1.25	243
1.26	254
1.27	264
1.28	274
1.29	285
1.30	296

M = Bending Moment, Kip ft. lbs. for balanced reinforcing.
M_1 = Moment in excess of M for beam size limited by conc.
M_c = Resist. Mom. Kip ft. lbs. of 1□″ compression steel
A_T = Sq. in. addn'l tensile steel for each 1□″ comp. steel.

UNIVERSAL BEAM TABLES

Rectangular Beams and Slabs with Balanced Reinforcing.
Rectangular Beams, Size Limited by Concrete Stress.
Tee Beams for Varying Slab Thickness.
Beams Reinforced for Compression.

$f_c = 875$
$f_s = 16000$
$n = 12$

$f'_c = 2500$
$f_c = 0.35 f'_c$

MOMENTS IN KIP FOOT POUNDS AND STEEL AREAS PER FOOT WIDTH

EFF. DEPTH	Rectang. Beams		TEE BEAMS FOR SLAB THICKNESSES SHOWN																		COMPRESSION REINF.	
			2″		2½″		3″		3½″		4″		4½″		5″		5½″		6″			
"d"	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M_c	A_T
1	.15	.13																				
½	.34	.20																				
2	.60	.26																				
½	.94	.33																				
3	1.4	.39																				
½	1.8	.46																				
4	2.4	.52																				
½	3.0	.59																				
5	3.8	.65																				
½	4.6	.72																				
6	5.4	.78	5.3	.76																	.5	.10
½	6.3	.85	6.1	.80																	.8	.14
7	7.4	.91	6.9	.84	7.4	.90															1.1	.17
½	8.5	.98	5.8	.87	8.4	.94															1.5	.20
8	9.5	1.04	8.6	.90	9.3	.98	9.6	1.04													1.8	.22
½	10.8	1.01	9.4	.93	10.3	1.02	10.8	1.09													2.2	.24
9	12.2	1.17	10.2	.95	11.4	1.06	12.0	1.14	12.1	1.17											2.5	.26
½	13.6	1.24	11.1	.98	12.4	1.09	13.2	1.18	13.5	1.23											2.9	.28
10	15.0	1.30	11.9	1.01	13.4	1.12	14.4	1.22	14.9	1.29											3.2	.29
½	16.6	1.37	12.9	1.03	14.5	1.15	15.6	1.26	16.2	1.34											3.6	.31
11	18.2	1.43	13.8	1.04	15.5	1.17	16.8	1.29	17.6	1.38	18.1	1.42									3.9	.32
½	19.9	1.50	14.6	1.05	16.6	1.19	18.0	1.32	19.1	1.42	19.7	1.47									4.2	.33
12	21.7	1.56	15.3	1.06	17.6	1.21	19.2	1.35	20.5	1.46	21.3	1.52	21.6	1.50							4.4	.34
½	23.5	1.63	16.2	1.07	18.6	1.22	20.5	1.38	22.0	1.49	22.9	1.56	23.4	1.59							4.9	.35
13	25.4	1.69	17.1	1.08	19.6	1.23	21.7	1.40	23.4	1.51	24.5	1.60	25.1	1.66	25.4	1.69					5.4	.36
½	27.5	1.75	17.9	1.09	20.7	1.25	22.9	1.42	24.9	1.54	26.0	1.64	27.0	1.71	27.4	1.75					5.8	.37
14	29.5	1.82	18.7	1.09	21.8	1.27	24.3	1.44	26.3	1.57	27.7	1.68	28.8	1.76	29.3	1.80	29.5	1.82			6.2	.38
½	31.8	1.89	19.6	1.10	22.9	1.29	25.6	1.46	27.8	1.60	29.4	1.71	30.6	1.80	31.3	1.85	31.6	1.89			6.6	.39
15	33.8	1.95	20.5	1.10	24.0	1.30	26.9	1.48	29.1	1.62	31.0	1.74	32.4	1.84	33.3	1.90	33.7	1.94			6.9	.40
½	36.3	2.01	21.4	1.11	25.1	1.31	28.1	1.49	30.6	1.64	32.6	1.77	34.3	1.88	35.3	1.94	35.9	1.99			7.3	.41
16	38.5	2.08	22.2	1.11	26.1	1.32	29.4	1.50	32.1	1.66	34.2	1.80	36.0	1.91	37.3	1.98	38.0	2.04	38.4	2.07	7.7	.41
½	41.0	2.15	23.1	1.12	27.2	1.33	30.6	1.51	33.6	1.68	36.0	1.82	37.9	1.94	39.3	2.02	40.3	2.09	40.8	2.14	8.1	.42
17	43.5	2.21	23.9	1.13	28.2	1.34	31.9	1.52	35.0	1.70	37.6	1.85	39.7	1.96	41.3	2.06	42.4	2.14	43.1	2.19	8.5	.42
18	48.8	2.34	25.6	1.14	30.4	1.36	34.5	1.55	38.0	1.73	41.0	1.89	43.4	2.02	45.3	2.13	46.8	2.22	47.9	2.29	9.2	.43
19	54.3	2.47	27.4	1.14	32.5	1.37	37.0	1.58	41.0	1.76	44.3	1.93	47.2	2.07	49.4	2.19	51.3	2.29	52.7	2.38	10.0	.44
20	60.2	2.60	29.2	1.15	34.8	1.38	39.6	1.60	44.0	1.79	47.6	1.96	50.9	2.11	53.6	2.25	55.8	2.36	57.5	2.45	10.8	.45
21	66.4	2.73	30.9	1.15	36.9	1.39	42.3	1.61	47.0	1.81	51.1	2.00	54.6	2.14	57.8	2.30	60.3	2.41	62.3	2.51	11.6	.46
22	72.8	2.86	32.6	1.16	39.0	1.40	44.8	1.63	49.9	1.83	54.5	2.03	58.5	2.18	61.9	2.34	64.9	2.47	67.3	2.58	12.4	.46
23	79.6	2.99	34.4	1.17	41.1	1.41	47.4	1.65	52.9	1.85	57.9	2.05	62.3	2.22	66.2	2.38	69.4	2.52	72.3	2.65	13.1	.47
24	86.6	3.12	36.1	1.18	43.4	1.42	50.0	1.66	55.9	1.87	61.4	2.07	66.0	2.25	70.3	2.42	74.0	2.56	77.0	2.70	13.9	.47
26	101.7	3.38			47.6	1.43	55.2	1.68	62.0	1.91	68.3	2.11	73.8	2.31	78.8	2.48	83.2	2.64	87.2	2.79	15.5	.48
28	107.9	3.64			51.9	1.45	60.3	1.70	68.0	1.94	75.0	2.15	81.4	2.34	87.3	2.54	92.5	2.71	97.2	2.87	17.1	.49
30	135.3	3.90			56.3	1.46	65.5	1.72	74.0	1.97	81.9	2.18	89.2	2.37	95.8	2.59	101.7	2.77	107.2	2.94	18.7	.50
32	154.1	4.16					70.8	1.74	80.3	1.99	88.9	2.21	97.0	2.40	104.4	2.64	111.2	2.82	117.4	3.00	20.3	.51
34	174.0	4.42					75.9	1.75	86.3	2.00	95.6	2.23	104.5	2.44	112.9	2.68	120.5	2.87	127.6	3.06	21.8	.51
36	195.1	4.68					81.2	1.76	92.3	2.01	102.6	2.25	112.5	2.48	121.5	2.71	130.1	2.91	138.0	3.11	23.4	.52
38	217.3	4.94									109.5	2.27	120.2	2.51	130.1	2.74	139.2	2.95	148.1	3.15	25.0	.52
40	240.9	5.20									116.4	2.29	127.9	2.54	139.0	2.76	149.0	2.98	158.5	3.18	26.6	.53
42	265.5	5.46									123.2	2.30	135.6	2.55	147.2	2.78	158.5	3.01	168.6	3.22	28.2	.53
44	291.3	5.72													156.1	2.81	168.0	3.04	179.1	3.26	29.8	.53
46	318.5	5.98													164.6	2.83	177.4	3.06	189.6	3.29	31.4	.54
48	346.9	6.24													173.5	2.85	187.0	3.08	200.0	3.32	33.0	.54
50	376.5	6.50																	210.4	3.35	34.6	.54
52	407.0	6.76																	220.5	3.37	36.2	.54
54	438.9	7.02																	230.9	3.38	37.8	.55
56	472.0	7.28																			39.4	.55
58	506.5	7.54																			41.0	.55
60	542.0	7.80																			42.6	.55
62	578.5	8.06																			44.2	.55
64	616.8	8.32																			45.8	.55

RECTANG. BEAMS LIMITED BY CONCRETE	
M_1/M	% A_s
1.01	103
1.02	106
1.03	110
1.04	114
1.05	117
1.06	121
1.07	125
1.08	129
1.09	133
1.10	137
1.11	141
1.12	145
1.13	150
1.14	154
1.15	159
1.16	164
1.17	169
1.18	175
1.19	181
1.20	187
1.21	193
1.22	198
1.23	204
1.24	211
1.25	218
1.26	225
1.27	232
1.28	239
1.29	248
1.30	256

M = Bending Moment, Kip ft. lbs. for balanced reinforcing.
M₁ = Moment in excess of M for beam size limited by conc.
Mc = Resist. Mom. Kip ft. lbs. of 1 □″ compression steel
Aᴛ = Sq. in. addn'l tensile steel for each 1 □″ comp. steel.

UNIVERSAL BEAM TABLES

Rectangular Beams and Slabs with Balanced Reinforcing.
Rectangular Beams, Size Limited by Concrete Stress.
Tee Beams for Varying Slab Thickness.
Beams Reinforced for Compression.

$f_c = 1000$
$f_s = 16000$
$n = 12$

$f'_c = 2500$
$f_c = 0.40 f'_c$

MOMENTS IN KIP FOOT POUNDS AND STEEL AREAS PER FOOT WIDTH

EFF. DEPTH	Rectang. Beams		TEE BEAMS FOR SLAB THICKNESSES SHOWN																		COMPRESSION REINF.	
			2″		2½″		3″		3½″		4″		4½″		5″		5½″		6″			
"d"	M	As	M	As	M	As	M	As	M	As	M	As	M	As	M	As	M	As	M	As	Mc	Aᴛ
1	.18	.16																				
½	.41	.24																				
2	.74	.32																				
½	1.1	.40																				
3	1.7	.48																				
½	2.3	.56																				
4	2.9	.64																				
½	3.7	.72																				
5	4.6	.80																				
½	5.6	.88																				
6	6.6	.96	6.4	.92	6.6	.96															.8	.16
½	7.7	1.04	6.7	.96	7.8	1.04															1.2	.20
7	9.0	1.13	7.0	1.00	8.9	1.10	9.0	1.12													1.6	.23
½	10.3	1.21	8.6	1.03	10.0	1.14	10.4	1.20													2.0	.26
8	11.8	1.29	10.1	1.06	11.1	1.18	11.6	1.26													2.3	.29
½	13.3	1.37	11.1	1.09	12.2	1.22	13.0	1.32													2.7	.32
9	14.9	1.45	12.0	1.11	13.4	1.26	14.4	1.37	14.7	1.44											3.1	.34
½	16.6	1.53	13.0	1.13	14.6	1.29	15.8	1.42	16.4	1.50											3.6	.36
10	18.4	1.61	14.0	1.15	15.7	1.32	17.1	1.46	17.9	1.55	18.4	1.60									4.0	.37
½	20.3	1.69	15.0	1.17	17.0	1.35	18.5	1.50	19.5	1.60	20.1	1.66									4.4	.38
11	22.2	1.77	15.9	1.18	18.3	1.38	19.9	1.54	21.1	1.65	21.9	1.72	22.3	1.76							4.7	.39
½	24.3	1.85	16.9	1.20	19.5	1.40	21.4	1.57	22.8	1.69	23.8	1.78	24.2	1.84							5.2	.41
12	26.4	1.93	17.8	1.21	20.6	1.42	22.8	1.60	24.4	1.73	25.5	1.83	26.4	1.90	26.5	1.93					5.6	.42
½	28.7	2.01	18.8	1.22	21.8	1.44	24.2	1.63	26.0	1.77	27.4	1.88	28.2	1.96	28.6	2.00					6.1	.43
13	31.0	2.09	19.8	1.23	23.0	1.46	25.6	1.65	27.6	1.80	29.2	1.92	30.2	2.01	30.7	2.06	31.0	2.09			6.5	.44
½	33.5	2.17	20.8	1.24	24.3	1.47	27.1	1.67	29.4	1.83	31.0	1.96	32.3	2.06	33.0	2.12	33.5	2.16			6.9	.45
14	36.0	2.25	21.8	1.25	25.5	1.49	28.5	1.69	31.0	1.86	32.9	2.00	34.4	2.11	35.3	2.18	35.9	2.23			7.3	.46
½	38.8	2.33	22.8	1.26	26.7	1.50	30.0	1.71	32.6	1.89	34.8	2.04	36.5	2.16	37.6	2.24	38.4	2.30			7.8	.47
15	41.3	2.41	23.7	1.27	27.9	1.51	31.4	1.72	34.3	1.91	36.6	2.06	38.5	2.20	39.9	2.29	40.8	2.36	41.3	2.40	8.2	.48
½	44.3	2.49	24.7	1.27	29.1	1.53	32.9	1.74	36.0	1.93	38.6	2.09	40.6	2.24	42.1	2.34	43.3	2.42	43.9	2.48	8.7	.49
16	47.0	2.57	25.7	1.28	30.4	1.54	34.4	1.76	37.6	1.95	40.5	2.12	42.7	2.27	44.4	2.38	45.8	2.47	46.5	2.54	9.1	.49
½	50.1	2.65	26.7	1.29	31.6	1.55	35.9	1.77	39.4	1.97	42.4	2.15	44.9	2.30	46.7	2.42	48.3	2.52	49.3	2.60	9.6	.50
17	53.1	2.73	27.6	1.29	32.7	1.56	37.3	1.78	41.0	2.00	44.3	2.17	46.9	2.34	49.0	2.46	50.8	2.56	51.9	2.65	10.0	.50
18	59.5	2.89	29.6	1.31	35.2	1.58	40.1	1.81	44.5	2.03	48.1	2.22	51.3	2.39	53.8	2.53	55.8	2.65	57.4	2.75	10.9	.51
19	66.3	3.05	31.6	1.32	37.9	1.59	43.1	1.84	47.9	2.06	52.0	2.26	55.5	2.44	58.5	2.60	60.9	2.83	62.9	2.84	11.8	.52
20	73.4	3.21	33.6	1.33	40.3	1.60	46.0	1.86	51.3	2.09	55.9	2.30	59.9	2.49	63.3	2.66	66.2	2.80	68.4	2.92	12.7	.53
21	81.0	3.38	35.6	1.34	42.6	1.61	49.0	1.88	54.6	2.11	59.8	2.33	64.2	2.53	68.0	2.71	71.3	2.86	74.0	3.00	13.5	.53
22	88.8	3.54	37.6	1.34	45.1	1.63	52.0	1.90	58.2	2.13	63.7	2.36	68.5	2.57	72.8	2.76	76.5	2.92	79.6	3.07	14.4	.54
23	97.1	3.70	39.5	1.35	47.6	1.64	54.9	1.92	61.5	2.15	67.5	2.39	72.9	2.61	77.5	2.80	81.8	2.97	85.2	3.13	15.3	.55
24	105.8	3.86	41.5	1.36	50.1	1.65	57.9	1.93	65.0	2.17	71.4	2.41	77.1	2.64	82.4	2.84	87.0	3.02	91.0	3.19	16.2	.55
26	124.2	4.18			55.0	1.66	63.8	1.95	71.9	2.21	79.3	2.46	86.0	2.70	92.2	2.91	97.7	3.10	102.5	3.28	18.1	.56
28	144.0	4.50			60.0	1.67	69.8	1.97	78.7	2.24	87.2	2.50	94.8	2.74	101.9	2.97	108.2	3.18	114.0	3.37	19.9	.57
30	165.4	4.83			65.0	1.68	75.7	1.99	85.7	2.27	95.0	2.53	103.6	2.78	111.5	3.02	119.0	3.24	125.6	3.45	21.7	.58
32	188.1	5.14					81.7	2.00	92.7	2.29	102.9	2.56	112.5	2.82	121.3	3.06	129.6	3.30	137.2	3.51	23.5	.59
34	212.4	5.46					87.6	2.01	99.7	2.31	110.9	2.59	121.2	2.85	131.1	3.10	140.4	3.35	149.0	3.57	25.3	.59
36	238.0	5.79					93.5	2.02	106.5	2.32	118.9	2.61	130.2	2.88	141.0	3.14	151.2	3.39	160.6	3.62	27.1	.60
38	266.0	6.11									126.7	2.63	139.2	2.91	151.0	3.17	162.0	3.43	172.4	3.67	28.8	.60
40	293.9	6.43									134.6	2.65	148.1	2.94	160.9	3.20	172.9	3.46	184.2	3.71	30.8	.61
42	324.1	6.75									142.4	2.66	157.0	2.95	170.5	3.23	183.8	3.50	196.0	3.75	32.6	.61
44	355.9	7.07													180.5	3.26	194.7	3.53	207.8	3.79	34.4	.62
46	388.8	7.39													190.5	3.28	205.6	3.56	219.7	3.82	36.3	.62
48	423.4	7.72													200.5	3.30	216.2	3.58	231.6	3.85	38.1	.62
50	459.3	8.04																	243.4	3.88	39.9	.62
52	496.8	8.36																	255.2	3.90	41.7	.63
54	536.0	8.68																	267.2	3.92	43.6	.63
56	576.0	9.00																			45.4	.63
58	618.0	9.32																			47.2	.63
60	661.8	9.64																			49.0	.64
62	706.0	9.97																			50.8	.64
64	752.2	10.28																			52.6	.64

RECTANG. BEAMS LIMITED BY CONCRETE	
M_1/M	% As
1.01	103
1.02	107
1.03	111
1.04	114
1.05	118
1.06	122
1.07	126
1.08	130
1.09	134
1.10	139
1.11	143
1.12	148
1.13	153
1.14	158
1.15	163
1.16	168
1.17	174
1.18	180
1.19	186
1.20	194
1.21	200
1.22	207
1.23	214
1.24	222
1.25	230
1.26	238
1.27	246
1.28	255
1.29	264
1.30	274

M = Bending Moment, Kip ft. lbs. for balanced reinforcing.
M_1 = Moment in excess of M for beam size limited by conc.
M_c = Resist. Mom. Kip ft. lbs. of 1 □″ compression steel
A_T = Sq. in. addn'l tensile steel for each 1 □″ comp. steel.

UNIVERSAL BEAM TABLES

Rectangular Beams and Slabs with Balanced Reinforcing.
Rectangular Beams, Size Limited by Concrete Stress.
Tee Beams for Varying Slab Thickness.
Beams Reinforced for Compression.

$f_c = 1125$
$f_s = 16000$
$n = 12$

$f'_c = 2500$
$f_c = 0.45 f'_c$

MOMENTS IN KIP FOOT POUNDS AND STEEL AREAS PER FOOT WIDTH

EFF. DEPTH	Rectang. Beams		TEE BEAMS FOR SLAB THICKNESSES SHOWN																		COMPRESSION REINF.	
			2″		2½″		3″		3½″		4″		4½″		5″		5½″		6″			
"d"	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M_c	A_T
1	.22	.19																				
½	.49	.29																				
2	.87	.39																				
½	1.4	.48																				
3	2.0	.58																				
½	2.7	.68																				
4	3.5	.77																				
½	4.4	.87																				
5	5.5	.97																				
½	6.6	1.06																				
6	7.9	1.16	7.4	1.07	7.8	1.15															1.1	.21
½	9.2	1.25	8.5	1.12	9.1	1.22															1.5	.25
7	10.7	1.35	9.5	1.16	10.4	1.29	10.5	1.35													1.9	.29
½	12.3	1.45	10.6	1.19	11.6	1.34	12.1	1.43													2.4	.32
8	13.9	1.54	11.6	1.22	12.9	1.39	13.6	1.50	13.8	1.54											2.8	.35
½	15.8	1.64	12.7	1.25	14.3	1.44	15.3	1.56	15.6	1.62											3.3	.38
9	17.7	1.74	13.8	1.28	15.5	1.48	16.8	1.61	17.4	1.70											3.7	.40
½	19.7	1.83	14.9	1.30	16.9	1.51	18.4	1.66	19.2	1.76											4.2	.42
10	21.8	1.93	15.9	1.32	18.3	1.54	19.9	1.70	21.0	1.82	21.6	1.90									4.6	.43
½	24.0	2.03	17.1	1.34	19.6	1.57	21.5	1.74	22.9	1.88	23.6	1.98									5.1	.45
11	26.4	2.13	18.2	1.35	20.9	1.59	23.0	1.78	24.7	1.93	25.6	2.04	26.2	2.10							5.6	.46
½	28.8	2.22	19.3	1.37	22.3	1.61	24.6	1.81	26.5	1.97	27.7	2.10	28.5	2.17							6.1	.48
12	31.4	2.31	20.4	1.38	23.6	1.63	26.3	1.84	28.3	2.01	29.8	2.15	30.7	2.24	31.3	2.30					6.6	.49
½	34.1	2.41	21.6	1.40	25.0	1.65	27.9	1.86	30.2	2.05	31.9	2.20	33.0	2.30	33.8	2.38					7.1	.50
13	36.9	2.51	22.7	1.41	26.3	1.67	29.5	1.89	32.0	2.09	33.9	2.24	35.3	2.36	36.3	2.45	36.8	2.50			7.5	.51
½	39.9	2.61	23.8	1.42	27.6	1.69	31.1	1.92	33.9	2.13	36.0	2.28	37.6	2.41	38.8	2.51	39.5	2.58			8.0	.52
14	42.8	2.70	24.8	1.43	29.0	1.70	32.7	1.94	35.7	2.16	38.2	2.32	39.9	2.46	41.3	2.58	42.1	2.65	42.6	2.68	8.5	.53
½	46.0	2.80	25.9	1.43	30.5	1.71	34.4	1.96	37.6	2.19	40.3	2.36	42.2	2.51	43.9	2.64	45.0	2.71	45.6	2.77	9.0	.54
15	49.1	2.89	27.0	1.44	31.9	1.73	36.0	1.98	39.5	2.21	42.4	2.39	44.6	2.55	46.4	2.69	47.8	2.77	48.6	2.85	9.5	.55
½	52.5	2.99	28.1	1.44	33.3	1.74	37.6	2.00	41.4	2.23	44.5	2.43	47.0	2.59	49.0	2.74	50.5	2.83	52.9	2.93	10.0	.56
16	55.8	3.09	29.2	1.45	34.6	1.75	39.3	2.02	43.3	2.25	46.6	2.46	49.4	2.63	51.6	2.78	53.3	2.89	54.5	2.99	10.5	.56
½	59.5	3.19	30.3	1.46	36.0	1.76	40.9	2.03	45.2	2.27	48.7	2.49	51.8	2.66	54.3	2.82	56.1	2.95	57.6	3.05	11.0	.57
17	63.1	3.28	31.4	1.47	37.4	1.77	42.5	2.04	47.1	2.29	50.9	2.51	54.2	2.70	56.9	2.86	59.0	3.00	60.6	3.11	11.5	.58
18	70.7	3.47	33.7	1.48	40.3	1.79	45.9	2.07	50.9	2.33	55.3	2.55	59.0	2.76	62.1	2.94	64.8	3.09	66.9	3.21	12.5	.59
19	78.8	3.66	35.9	1.49	42.9	1.81	49.3	2.09	54.8	2.36	59.6	2.59	63.8	2.81	67.5	3.00	70.5	3.17	73.0	3.31	13.5	.60
20	87.3	3.86	38.2	1.50	45.7	1.83	52.5	2.11	58.5	2.39	64.0	2.63	68.8	2.86	72.9	3.06	76.4	3.24	79.4	3.40	14.5	.61
21	96.2	4.05	40.4	1.51	48.5	1.84	55.9	2.13	62.4	2.41	68.2	2.67	73.6	2.91	78.2	3.11	82.3	3.31	85.6	3.48	15.5	.61
22	105.5	4.25	42.6	1.52	51.3	1.85	59.1	2.15	66.3	2.43	72.8	2.70	78.5	2.95	83.6	3.16	88.2	3.37	92.0	3.55	16.5	.62
23	115.4	4.44	44.7	1.53	54.0	1.86	62.5	2.17	70.2	2.45	77.1	2.73	83.4	2.99	89.0	3.21	94.2	3.43	98.4	3.62	17.6	.63
24	125.6	4.63	47.1	1.53	56.9	1.87	65.8	2.19	74.0	2.47	81.5	2.76	88.4	3.02	94.5	3.26	100.0	3.49	104.9	3.68	18.6	.63
26	147.4	5.02			62.4	1.89	72.5	2.21	81.8	2.50	90.4	2.81	98.2	3.07	105.4	3.32	111.9	3.56	117.8	3.78	20.6	.64
28	171.0	5.40			68.0	1.90	79.1	2.23	89.5	2.54	99.1	2.85	108.1	3.12	116.5	3.39	124.0	3.65	130.8	3.87	22.6	.65
30	196.4	5.79			73.8	1.91	85.9	2.25	97.4	2.57	108.1	2.88	118.0	3.17	127.4	3.45	136.0	3.71	143.9	3.95	24.7	.66
32	223.4	6.18					92.6	2.27	105.2	2.60	117.0	2.91	128.0	3.21	138.5	3.50	148.0	3.76	157.1	4.02	26.7	.67
34	252.1	6.57					99.3	2.29	113.0	2.63	126.0	2.94	138.1	3.25	149.4	3.54	160.1	3.81	170.1	4.09	28.8	.68
36	282.8	6.95					106.0	2.30	120.9	2.65	134.7	2.97	148.1	3.28	160.6	3.58	172.4	3.86	183.5	4.14	30.8	.68
38	315.0	7.34									143.7	2.99	158.2	3.30	171.8	3.61	184.4	3.90	196.6	4.18	32.9	.69
40	349.7	7.72									152.6	3.01	168.2	3.32	182.8	3.64	196.6	3.94	209.9	4.22	34.9	.69
42	384.6	8.11									161.6	3.03	178.2	3.34	193.9	3.67	209.0	3.98	223.1	4.27	37.0	.70
44	422.1	8.50													205.1	3.70	221.1	4.01	236.6	4.31	39.0	.70
46	461.3	8.88													216.2	3.72	233.5	4.04	249.8	4.34	41.1	.70
48	502.8	9.27													227.2	3.74	245.9	4.06	263.1	4.37	43.1	.71
50	545.5	9.65																	276.9	4.40	45.2	.71
52	590.0	10.04																	289.6	4.43	47.2	.71
54	636.3	10.42																	303.2	4.46	49.3	.71
56	684.0	10.81																			51.3	.72
58	734.0	11.20																			53.4	.72
60	785.7	11.59																			55.5	.72
62	838.6	11.97																			57.5	.72
64	894.0	12.35																			59.6	.72

RECTANG. BEAMS LIMITED BY CONCRETE	
M_1/M	% A_s
1.01	103
1.02	107
1.03	111
1.04	114
1.05	118
1.06	122
1.07	126
1.08	130
1.09	135
1.10	140
1.11	145
1.12	151
1.13	157
1.14	163
1.15	169
1.16	175
1.17	182
1.18	189
1.19	196
1.20	203
1.21	210
1.22	217
1.23	225
1.24	234
1.25	243
1.26	254
1.27	264
1.28	274
1.29	285
1.30	296

M = Bending Moment, Kip ft. lbs. for balanced reinforcing.
M_1 = Moment in excess of M for beam size limited by conc.
M_c = Resist. Mom. Kip ft. lbs. of 1□″ compression steel
A_T = Sq. in. addn'l tensile steel for each 1□″ comp. steel.

UNIVERSAL BEAM TABLES

Rectangular Beams and Slabs with Balanced Reinforcing.
Rectangular Beams, Size Limited by Concrete Stress.
Tee Beams for Varying Slab Thickness.
Beams Reinforced for Compression.

$f_c = 700$
$f_s = 18000$
$n = 15$

$f'_c = 2000$
$f_c = 0.35 f'_c$

MOMENTS IN KIP FOOT POUNDS AND STEEL AREAS PER FOOT WIDTH

EFF. DEPTH	Rectang. Beams		TEE BEAMS FOR SLAB THICKNESSES SHOWN																		COMPRESSION REINF.	
			2″		2½″		3″		3½″		4″		4½″		5″		5½″		6″			
"d"	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M_c	A_T
1	.11	.09																				
½	.25	.13																				
2	.45	.17																				
½	.71	.21																				
3	1.0	.26																				
½	1.4	.30																				
4	1.8	.34																				
½	2.3	.39																				
5	2.8	.43																				
½	3.4	.47																				
6	4.1	.52	4.1	.51																	.31	.05
½	4.8	.56	4.8	.54																	.62	.09
7	5.5	.60	5.3	.57	5.5	.60															.92	.12
½	6.4	.64	6.0	.60	6.4	.64															1.2	.15
8	7.2	.69	6.6	.62	7.1	.67															1.6	.18
½	8.2	.73	7.4	.64	7.9	.70	8.1	.74													2.0	.20
9	9.2	.77	8.0	.65	8.7	.73	9.1	.77													2.3	.22
½	10.2	.82	8.7	.67	9.6	.75	10.0	.80	10.2	.82											2.7	.24
10	11.3	.86	9.3	.68	10.4	.77	11.0	.83	11.3	.86											3.0	.25
½	12.5	.90	10.0	.69	11.3	.79	12.0	.85	12.4	.90											3.4	.26
11	13.7	.95	10.6	.70	12.0	.81	13.0	.88	13.5	.93	13.7	.95									3.7	.28
½	15.0	.99	11.4	.71	12.9	.83	14.0	.90	14.6	.96	15.0	.98									4.1	.29
12	16.3	1.03	12.0	.72	13.7	.84	14.9	.92	15.7	.99	16.2	1.02									4.5	.30
½	17.7	1.07	12.8	.73	14.6	.85	15.9	.94	16.9	1.02	17.5	1.06	17.7	1.08							4.9	.31
13	19.1	1.12	13.4	.74	15.4	.86	16.9	.96	18.0	1.04	18.7	1.09	19.1	1.11							5.2	.32
½	20.7	1.16	14.1	.74	16.3	.87	17.9	.98	19.2	1.06	20.0	1.11	20.5	1.15							5.6	.32
14	22.2	1.20	14.8	.75	17.1	.88	18.9	.99	20.3	1.08	21.3	1.14	21.9	1.18	22.1	1.20					6.0	.33
½	23.9	1.25	15.5	.76	18.0	.89	19.9	1.00	21.5	1.10	22.6	1.17	23.3	1.21	23.8	1.24					6.4	.34
15	25.5	1.29	16.1	.77	18.8	.90	20.9	1.02	22.6	1.12	23.9	1.19	24.7	1.24	25.3	1.28	25.4	1.29			6.8	.35
½	27.3	1.33	16.8	.77	19.7	.91	21.9	1.03	23.8	1.14	25.2	1.21	26.2	1.27	27.0	1.31	27.2	1.33			7.2	.35
16	29.0	1.38	17.5	.78	20.5	.92	23.0	1.04	25.0	1.16	26.5	1.23	27.7	1.30	28.5	1.34	28.9	1.37			7.6	.36
½	30.8	1.42	18.3	.78	21.4	.93	24.0	1.05	26.2	1.17	27.9	1.25	29.2	1.32	30.2	1.37	30.6	1.40			8.0	.36
17	32.7	1.46	18.9	.78	22.2	.94	25.0	1.06	27.3	1.18	29.2	1.27	30.6	1.34	31.6	1.40	32.3	1.44	32.6	1.46	8.3	.37
18	36.7	1.55	20.3	.79	23.9	.95	27.0	1.08	29.7	1.20	31.8	1.30	33.6	1.39	34.9	1.45	35.8	1.50	36.4	1.53	9.1	.38
19	40.8	1.63	21.7	.80	25.6	.96	29.1	1.10	32.0	1.22	34.5	1.33	36.6	1.43	38.2	1.50	39.3	1.56	40.2	1.60	9.9	.39
20	45.2	1.72	23.0	.81	27.4	.97	31.1	1.11	34.4	1.25	37.2	1.36	39.6	1.46	41.4	1.54	42.9	1.61	44.0	1.66	10.7	.40
21	49.9	1.81	24.4	.81	29.1	.98	33.2	1.13	36.9	1.27	39.9	1.38	42.6	1.49	44.8	1.58	46.5	1.65	47.9	1.71	11.5	.40
22	54.8	1.89	25.8	.82	30.8	.99	35.3	1.14	39.2	1.28	42.6	1.40	45.5	1.52	48.1	1.61	50.1	1.69	51.8	1.76	12.3	.41
23	59.8	1.98	27.2	.82	32.6	.99	37.3	1.15	41.6	1.29	45.4	1.43	48.5	1.54	51.4	1.64	53.8	1.73	55.7	1.81	13.1	.42
24	65.2	2.06	28.6	.83	34.3	1.00	39.4	1.16	44.0	1.31	48.1	1.45	51.6	1.57	54.8	1.67	57.5	1.77	59.7	1.85	13.9	.42
26	76.5	2.24			37.7	1.02	43.6	1.18	48.8	1.34	53.5	1.48	57.8	1.60	61.6	1.73	64.8	1.83	67.6	1.92	15.5	.43
28	88.7	2.41			41.2	1.03	47.7	1.20	53.7	1.36	59.1	1.51	64.0	1.64	68.3	1.77	72.2	1.88	75.7	1.99	17.1	.44
30	101.8	2.58			44.7	1.04	51.9	1.21	58.7	1.38	64.6	1.53	70.0	1.67	75.2	1.81	79.6	1.93	83.8	2.04	18.7	.45
32	115.8	2.75					56.1	1.22	63.3	1.39	70.1	1.55	76.2	1.70	82.0	1.84	87.1	1.97	91.8	2.09	20.3	.45
34	130.8	2.92					60.2	1.23	68.1	1.40	75.7	1.57	82.4	1.72	88.9	1.87	94.7	2.00	100.0	2.13	22.0	.46
36	146.6	3.09					64.3	1.24	73.0	1.42	81.1	1.59	88.8	1.75	95.6	1.89	102.2	2.03	108.3	2.17	23.6	.46
38	163.3	3.27									86.7	1.60	95.0	1.76	102.5	1.92	109.7	2.06	116.3	2.20	25.2	.47
40	181.0	3.44									92.2	1.61	101.2	1.78	109.6	1.94	117.3	2.09	124.5	2.23	26.8	.47
42	199.5	3.61									97.6	1.62	107.3	1.79	116.3	1.96	125.0	2.11	132.9	2.26	28.4	.47
44	219.0	3.78													123.4	1.97	132.6	2.13	141.1	2.28	30.1	.48
46	239.3	3.95													130.1	1.99	140.2	2.15	149.2	2.30	31.7	.48
48	260.6	4.13													137.2	2.00	147.6	2.17	157.8	2.33	33.3	.48
50	282.8	4.30																	166.1	2.35	34.9	.49
52	305.9	4.47																	174.0	2.36	36.6	.49
54	329.8	4.64																	182.6	2.38	38.2	.49
56	354.7	4.81																			39.8	.49
58	380.5	4.99																			41.5	.49
60	407.2	5.16																			43.1	.50
62	434.8	5.33																			44.7	.50
64	463.3	5.50																			46.3	.50

RECTANG. BEAMS LIMITED BY CONCRETE	
M_1/M	%A_s
1.01	103
1.02	106
1.03	109
1.04	112
1.05	116
1.06	120
1.07	124
1.08	127
1.09	130
1.10	134
1.11	138
1.12	142
1.13	146
1.14	151
1.15	156
1.16	161
1.17	165
1.18	169
1.19	174
1.20	179
1.21	185
1.22	191
1.23	196
1.24	201
1.25	206
1.26	212
1.27	219
1.28	226
1.29	233
1.30	240

M = Bending Moment, Kip ft. lbs. for balanced reinforcing.
M_1 = Moment in excess of M for beam size limited by conc.
M_c = Resist. Mom. Kip ft. lbs. of 1□" compression steel
A_T = Sq. in. addn'l tensile steel for each 1□" comp. steel.

UNIVERSAL BEAM TABLES

Rectangular Beams and Slabs with Balanced Reinforcing.
Rectangular Beams, Size Limited by Concrete Stress.
Tee Beams for Varying Slab Thickness.
Beams Reinforced for Compression.

$f_c = 800$
$f_s = 18000$
$n = 15$

$f'_c = 2000$
$f_c = 0.40 f'_c$

MOMENTS IN KIP FOOT POUNDS AND STEEL AREAS PER FOOT WIDTH

EFF. DEPTH	Rectang. Beams		TEE BEAMS FOR SLAB THICKNESSES SHOWN																		COMPRESSION REINF.	
			2"		2½"		3"		3½"		4"		4½"		5"		5½"		6"			
"d"	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M_c	A_T
1	.14	.11																				
½	.31	.16																				
2	.56	.21																				
½	.87	.27																				
3	1.3	.32																				
½	1.6	.37																				
4	2.2	.43																				
½	2.8	.48																				
5	3.5	.53																				
½	4.2	.59																				
6	5.0	.64	4.9	.62																	.62	.10
½	5.9	.69	5.7	.66																	.83	.14
7	6.8	.75	6.4	.69	6.7	.74															1.3	.18
½	7.8	.80	7.2	.71	7.7	.78															1.7	.21
8	8.9	.85	7.9	.73	8.6	.81	8.9	.85													2.1	.23
½	10.0	.91	8.7	.75	9.5	.84	10.0	.89													2.3	.26
9	11.2	.96	9.4	.77	10.4	.87	11.0	.93	11.2	.96											2.5	.28
½	12.5	1.01	10.2	.79	11.4	.90	12.1	.97	12.5	1.01											3.1	.30
10	13.9	1.07	10.9	.80	12.3	.92	13.2	1.00	13.7	1.05	13.9	1.07									3.7	.31
½	15.3	1.12	11.7	.81	13.3	.94	14.3	1.03	15.0	1.09	15.3	1.12									4.2	.33
11	16.8	1.17	12.5	.82	14.2	.95	15.4	1.05	16.3	1.12	16.7	1.16	16.8	1.17							4.6	.34
½	18.3	1.23	13.3	.83	15.2	.97	16.6	1.08	17.6	1.16	18.2	1.20	18.4	1.22							5.0	.35
12	20.0	1.28	14.0	.84	16.1	.99	17.7	1.10	18.8	1.19	19.6	1.24	19.9	1.27							5.4	.36
½	21.7	1.33	14.8	.85	17.1	1.00	18.9	1.12	20.2	1.22	21.1	1.28	21.5	1.32	21.6	1.33					5.9	.37
13	23.4	1.39	15.6	.86	18.0	1.01	20.0	1.14	21.5	1.24	22.5	1.31	23.1	1.36	23.4	1.39					6.3	.38
½	25.3	1.44	16.4	.87	19.0	1.03	21.2	1.16	22.8	1.26	24.0	1.34	24.9	1.40	25.2	1.44					6.8	.39
14	27.2	1.49	17.2	.88	20.0	1.04	22.3	1.17	24.1	1.28	25.4	1.37	26.6	1.44	27.0	1.48	27.2	1.49			7.2	.40
½	29.2	1.55	18.0	.88	21.0	1.05	23.6	1.20	25.4	1.30	26.9	1.40	28.2	1.47	28.8	1.52	29.2	1.54			7.7	.40
15	31.2	1.60	18.8	.89	21.9	1.06	24.9	1.22	26.7	1.32	28.4	1.42	29.7	1.50	30.5	1.56	31.1	1.59	31.2	1.60	8.1	.41
½	33.4	1.66	19.6	.89	22.9	1.06	25.9	1.24	28.1	1.34	30.0	1.45	31.4	1.53	32.4	1.59	33.1	1.63	33.3	1.65	8.6	.42
16	35.5	1.71	20.3	.90	23.9	1.07	26.9	1.25	29.4	1.36	31.5	1.47	33.1	1.56	34.2	1.62	35.0	1.67	35.4	1.70	9.0	.43
½	37.8	1.76	21.1	.90	24.9	1.08	28.1	1.26	30.8	1.38	33.0	1.49	34.8	1.59	36.1	1.66	37.0	1.71	37.6	1.75	9.5	.43
17	40.1	1.81	21.9	.91	25.9	1.09	29.3	1.27	32.1	1.39	34.5	1.51	36.4	1.61	37.9	1.69	39.0	1.75	39.7	1.79	9.9	.44
18	44.9	1.92	23.5	.92	27.8	1.10	31.6	1.28	34.8	1.41	37.6	1.54	39.8	1.65	41.6	1.74	43.0	1.81	44.0	1.87	10.8	.45
19	50.1	2.03	25.1	.93	29.8	1.11	33.9	1.30	37.5	1.44	40.6	1.57	43.2	1.69	45.4	1.79	47.1	1.87	48.4	1.94	11.7	.46
20	55.5	2.13	26.7	.93	31.8	1.12	36.3	1.31	40.3	1.46	43.8	1.60	46.7	1.73	49.2	1.83	51.2	1.92	52.8	2.00	12.6	.47
21	61.2	2.24	28.3	.94	33.7	1.13	38.7	1.33	43.0	1.48	46.8	1.63	50.1	1.76	53.0	1.87	55.3	1.97	57.2	2.06	13.5	.47
22	67.1	2.35	29.8	.95	35.7	1.14	41.0	1.34	45.7	1.49	49.9	1.65	53.6	1.79	56.8	1.91	59.5	2.02	61.8	2.11	14.4	.48
23	73.4	2.45	31.4	.95	37.7	1.15	43.4	1.35	48.5	1.51	53.1	1.67	57.1	1.81	60.7	1.94	63.7	2.06	66.2	2.16	15.3	.49
24	79.9	2.56	33.0	.96	39.7	1.16	45.7	1.36	51.2	1.53	56.1	1.69	60.6	1.84	64.5	1.97	67.9	2.09	70.8	2.20	16.3	.49
26	93.7	2.77			43.6	1.18	50.5	1.37	56.8	1.55	62.4	1.72	67.6	1.88	72.2	2.02	76.3	2.16	80.0	2.28	18.1	.50
28	108.7	2.99			47.6	1.19	55.2	1.38	62.3	1.58	68.8	1.75	74.6	1.92	80.0	2.07	84.9	2.21	89.1	2.34	19.9	.51
30	124.8	3.20			51.6	1.20	60.0	1.40	67.8	1.59	75.0	1.78	81.7	1.95	87.7	2.11	93.3	2.26	98.4	2.40	21.8	.52
32	142.0	3.41					64.8	1.41	73.4	1.61	81.4	1.80	88.7	1.98	95.6	2.15	102.0	2.30	107.7	2.45	23.6	.53
34	160.3	3.63					69.5	1.42	78.8	1.62	87.7	1.82	95.9	2.00	103.4	2.17	110.6	2.34	117.0	2.49	25.5	.53
36	179.7	3.84					74.3	1.43	84.3	1.64	93.9	1.84	103.0	2.03	111.3	2.20	119.1	2.37	126.3	2.53	27.3	.54
38	200.2	4.05									100.3	1.85	110.2	2.05	119.3	2.23	127.8	2.40	135.7	2.57	29.2	.54
40	221.9	4.27									106.7	1.87	117.3	2.06	127.2	2.25	136.4	2.43	145.3	2.60	31.0	.54
42	244.6	4.48									113.1	1.88	124.2	2.08	134.9	2.27	145.2	2.45	154.8	2.63	32.9	.55
44	268.5	4.69													142.8	2.29	153.9	2.48	164.2	2.66	34.8	.55
46	293.4	4.91													150.6	2.30	162.5	2.50	173.5	2.68	36.6	.55
48	319.5	5.12													158.9	2.32	171.0	2.51	183.1	2.70	38.5	.56
50	346.7	5.33																	192.3	2.72	40.3	.56
52	375.0	5.55																	202.0	2.74	42.2	.56
54	404.4	5.76																	211.3	2.75	44.0	.57
56	434.9	5.97																			45.9	.57
58	466.5	6.19																			47.8	.57
60	499.2	6.40																			49.6	.57
62	533.0	6.61																			51.5	.57
64	568.0	6.83																			53.4	.57

RECTANG. BEAMS LIMITED BY CONCRETE	
M_1/M	%A_s
1.01	103
1.02	106
1.03	110
1.04	114
1.05	117
1.06	121
1.07	125
1.08	129
1.09	133
1.10	137
1.11	141
1.12	145
1.13	150
1.14	154
1.15	159
1.16	164
1.17	169
1.18	175
1.19	181
1.20	187
1.21	193
1.22	198
1.23	204
1.24	211
1.25	218
1.26	225
1.27	232
1.28	239
1.29	248
1.30	256

M = Bending Moment, Kip ft. lbs. for balanced reinforcing.
M₁ = Moment in excess of M for beam size limited by conc.
Mc = Resist. Mom. Kip ft. lbs. of 1 □″ compression steel
Aᴛ = Sq. in. addn'l tensile steel for each 1 □″ comp. steel.

UNIVERSAL BEAM TABLES

Rectangular Beams and Slabs with Balanced Reinforcing.
Rectangular Beams, Size Limited by Concrete Stress.
Tee Beams for Varying Slab Thickness.
Beams Reinforced for Compression.

$f_c = 900$
$f_s = 18000$
$n = 15$

$f'_c = 2000$
$f_c = 0.45 f'_c$

MOMENTS IN KIP FOOT POUNDS AND STEEL AREAS PER FOOT WIDTH

EFF. DEPTH	Rectang. Beams		TEE BEAMS FOR SLAB THICKNESSES SHOWN																		COMPRESSION REINF.	
			2″		2½″		3″		3½″		4″		4½″		5″		5½″		6″			
"d"	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M_c	A_T
1	.17	.13																				
½	.37	.19																				
2	.66	.26																				
½	1.0	.32																				
3	1.5	.39																				
½	2.0	.45																				
4	2.7	.51																				
½	3.4	.58																				
5	4.1	.64																				
½	5.0	.71																				
6	6.0	.77	5.7	.73	5.9	.77															.93	.16
½	7.0	.84	6.6	.77	6.9	.83															1.4	.20
7	8.1	.90	7.4	.80	7.9	.88	8.1	.90													1.8	.23
½	9.3	.96	8.3	.83	9.0	.92	9.3	.96													2.2	.26
8	10.6	1.03	9.1	.85	10.0	.95	10.5	1.01													2.6	.29
½	11.9	1.09	10.0	.87	11.1	.98	11.7	1.06	11.9	1.09											3.1	.32
9	13.4	1.16	10.8	.89	12.1	1.01	12.9	1.10	13.3	1.15											3.6	.34
½	14.9	1.22	11.7	.91	13.2	1.04	14.2	1.14	14.7	1.20	14.9	1.22									4.1	.36
10	16.5	1.29	12.6	.92	14.2	1.06	15.4	1.17	16.1	1.24	16.5	1.28									4.5	.37
½	18.2	1.35	13.5	.94	15.3	1.08	16.7	1.20	17.6	1.28	18.1	1.33	18.2	1.35							5.0	.39
11	20.0	1.41	14.3	.95	16.4	1.10	17.9	1.23	19.0	1.32	19.7	1.38	20.0	1.41							5.4	.40
½	21.9	1.48	15.2	.96	17.5	1.12	19.2	1.26	20.5	1.36	21.3	1.43	21.8	1.47							5.9	.42
12	23.8	1.54	16.1	.97	18.5	1.14	20.5	1.28	21.9	1.39	22.9	1.47	23.5	1.52	23.8	1.54					6.4	.43
½	25.8	1.61	17.0	.97	19.6	1.15	21.8	1.30	23.4	1.42	24.6	1.51	25.4	1.57	25.8	1.60					6.9	.44
13	27.9	1.67	17.8	.98	20.7	1.16	23.1	1.32	24.9	1.44	26.2	1.54	27.2	1.61	27.7	1.65	28.0	1.67			7.4	.45
½	30.2	1.74	18.7	.99	21.8	1.18	24.4	1.34	26.4	1.47	27.9	1.57	29.1	1.65	29.8	1.70	30.1	1.73			7.9	.46
14	32.4	1.80	19.6	1.00	22.9	1.19	25.7	1.35	27.9	1.49	29.6	1.60	30.9	1.69	31.8	1.75	32.2	1.79	32.3	1.80	8.4	.47
½	34.8	1.87	20.5	1.00	24.0	1.20	27.0	1.37	29.4	1.51	31.3	1.63	32.8	1.73	33.9	1.79	34.4	1.84	34.7	1.86	8.9	.48
15	37.2	1.93	21.4	1.01	25.1	1.21	28.3	1.38	30.9	1.53	33.0	1.65	34.6	1.76	35.9	1.83	36.6	1.89	37.1	1.92	9.4	.48
½	39.8	2.00	22.3	1.02	26.2	1.22	29.6	1.40	32.4	1.55	34.7	1.68	36.5	1.79	38.0	1.87	38.9	1.94	39.5	1.98	9.9	.49
16	42.3	2.06	23.2	1.03	27.3	1.23	30.9	1.41	33.9	1.56	36.4	1.70	38.4	1.81	40.0	1.91	41.1	1.98	41.9	2.03	10.4	.50
½	45.1	2.13	24.1	1.03	28.4	1.23	32.2	1.42	35.4	1.58	38.2	1.72	40.3	1.84	42.1	1.94	43.4	2.02	44.3	2.08	10.9	.50
17	47.8	2.19	24.9	1.03	29.5	1.24	33.5	1.43	36.9	1.60	39.9	1.74	42.2	1.87	44.1	1.97	45.6	2.05	46.7	2.12	11.4	.51
18	53.6	2.31	26.7	1.04	31.7	1.26	36.2	1.45	40.0	1.62	43.3	1.78	46.1	1.91	48.4	2.03	50.2	2.12	51.6	2.20	12.5	.52
19	59.7	2.44	28.5	1.05	34.0	1.27	38.8	1.47	43.0	1.65	46.8	1.81	49.9	1.95	52.6	2.08	54.8	2.19	56.5	2.27	13.5	.53
20	66.1	2.57	30.3	1.06	36.2	1.28	41.4	1.49	46.1	1.67	50.3	1.84	53.8	1.99	56.9	2.13	59.5	2.24	61.6	2.34	14.5	.54
21	72.9	2.70	32.1	1.07	38.4	1.29	44.1	1.50	49.2	1.69	53.8	1.87	57.7	2.03	61.2	2.17	64.1	2.29	66.6	2.40	15.5	.54
22	80.0	2.83	34.0	1.07	40.6	1.30	46.8	1.51	52.3	1.71	57.2	1.89	61.7	2.06	65.5	2.20	68.9	2.34	71.7	2.46	16.6	.55
23	87.5	2.96	35.6	1.08	42.9	1.31	49.4	1.53	55.4	1.73	60.7	1.91	65.6	2.08	69.8	2.24	73.5	2.38	76.7	2.50	17.6	.56
24	95.2	3.09	37.4	1.08	45.1	1.32	52.1	1.54	58.5	1.74	64.2	1.93	69.4	2.11	74.1	2.27	78.3	2.42	82.0	2.55	18.6	.56
28	111.8	3.34			49.1	1.34	57.4	1.56	64.6	1.77	71.3	1.97	77.4	2.16	82.9	2.33	87.8	2.49	92.2	2.63	20.7	.57
28	129.6	3.60			53.5	1.35	62.8	1.57	70.9	1.79	78.4	2.00	85.3	2.19	91.6	2.38	97.4	2.54	102.7	2.70	22.8	.58
30	148.8	3.86			58.1	1.36	68.1	1.59	77.1	1.81	85.5	2.03	93.3	2.23	100.4	2.42	107.1	2.60	113.1	2.76	24.8	.59
32	169.3	4.11					73.5	1.60	83.3	1.83	92.6	2.05	101.3	2.26	109.3	2.45	116.7	2.64	123.5	2.81	26.9	.60
34	191.1	4.37					78.8	1.61	89.6	1.85	99.8	2.07	109.1	2.28	118.0	2.48	126.3	2.68	134.1	2.86	29.0	.60
36	214.2	4.63					84.2	1.62	95.9	1.86	106.9	2.09	117.2	2.31	126.9	2.51	136.1	2.71	144.5	2.90	31.1	.61
38	238.7	4.89									114.1	2.11	125.4	2.33	135.8	2.54	145.7	2.74	155.2	2.94	33.2	.61
40	264.5	5.14									121.2	2.12	133.3	2.35	144.7	2.56	155.5	2.77	165.8	2.97	35.3	.62
42	291.6	5.40									128.2	2.13	141.3	2.36	153.4	2.58	165.4	2.80	176.3	3.00	37.3	.62
44	320.0	5.66													162.5	2.60	175.1	2.82	186.9	3.03	39.4	.63
46	349.8	5.91													171.6	2.62	185.1	2.84	197.7	3.05	41.5	.63
48	380.9	6.17													180.5	2.64	194.5	2.86	208.4	3.08	43.6	.63
50	413.3	6.43																	219.0	3.10	45.7	.64
52	447.0	6.69																	229.6	3.11	47.8	.64
54	482.0	6.94																	245.6	3.13	49.9	.64
56	518.4	7.20																			52.0	.64
58	556.1	7.46																			54.1	.64
60	595.1	7.71																			56.2	.65
62	635.4	7.97																			58.3	.65
64	677.1	8.23																			60.5	.65

RECTANG. BEAMS LIMITED BY CONCRETE	
M_1/M	%A_s
1.01	103
1.02	107
1.03	111
1.04	114
1.05	118
1.06	122
1.07	126
1.08	130
1.09	134
1.10	139
1.11	143
1.12	148
1.13	153
1.14	158
1.15	163
1.16	168
1.17	174
1.18	180
1.19	186
1.20	193
1.21	200
1.22	207
1.23	214
1.24	222
1.25	230
1.26	238
1.27	246
1.28	255
1.29	264
1.30	274

M = Bending Moment, Kip ft. lbs. for balanced reinforcing.
M_1 = Moment in excess of M for beam size limited by conc.
M_c = Resist. Mom. Kip ft. lbs. of 1 □″ compression steel
A_T = Sq. in. addn'l tensile steel for each 1 □″ comp. steel.

UNIVERSAL BEAM TABLES

Rectangular Beams and Slabs with Balanced Reinforcing.
Rectangular Beams, Size Limited by Concrete Stress.
Tee Beams for Varying Slab Thickness.
Beams Reinforced for Compression.

$f_c = 875$
$f_s = 18000$
$n = 12$

$f'_c = 2500$
$f_c = 0.35 f'_c$

MOMENTS IN KIP FOOT POUNDS AND STEEL AREAS PER FOOT WIDTH

EFF. DEPTH	Rectang. Beams		TEE BEAMS FOR SLAB THICKNESSES SHOWN																		COMPRESSION REINF.		RECTANG. BEAMS LIMITED BY CONCRETE	
			2″		2½″		3″		3½″		4″		4½″		5″		5½″		6″					
"d"	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M_c	A_T	M_1/M	%A_s
1	.14	.11																						
½	.32	.16																					1.01	103
2	.57	.21																						
½	.88	.27																					1.02	106
3	1.3	.32																						
½	1.7	.38																					1.03	109
4	2.3	.43																						
½	2.9	.48																					1.04	112
5	3.5	.54																						
½	4.3	.59																					1.05	116
6	5.1	.64	5.1	.64																	.31	.05		
½	6.0	.70	6.0	.68																	.61	.09	1.06	120
7	6.9	.75	6.6	.71	6.9	.75															.90	.12		
½	8.0	.81	7.5	.75	8.0	.80															1.3	.15	1.07	124
8	9.0	.86	8.3	.77	8.9	.84															1.6	.17		
½	10.2	.91	9.2	.80	9.9	.88	10.1	.94													1.9	.19	1.08	127
9	11.5	.97	10.0	.81	10.9	.91	11.4	.96													2.2	.21		
½	12.8	1.02	10.9	.83	12.0	.94	12.5	1.00	12.7	1.00											2.6	.23	1.09	130
10	14.1	1.07	11.6	.85	13.0	.96	13.8	1.04	14.1	1.07											2.9	.24		
½	15.6	1.13	12.5	.87	14.1	.99	15.0	1.07	15.5	1.13											3.3	.26	1.10	134
11	17.1	1.18	13.3	.88	15.0	1.01	16.2	1.10	16.9	1.16	17.1	1.19									3.7	.27		
½	18.7	1.24	14.2	.89	16.1	1.04	17.5	1.13	18.3	1.20	18.8	1.24									4.1	.28	1.11	138
12	20.4	1.29	15.0	.90	17.1	1.05	18.6	1.15	19.6	1.24	20.2	1.28									4.4	.29		
½	22.1	1.34	16.0	.91	18.3	1.06	19.9	1.18	21.1	1.28	21.9	1.32	22.2	1.34							4.6	.30	1.12	142
13	23.9	1.40	16.8	.92	19.2	1.07	21.1	1.20	22.5	1.30	23.4	1.36	23.9	1.39							5.1	.31	1.13	146
½	25.8	1.45	17.6	.93	20.4	1.08	22.4	1.22	24.0	1.32	25.0	1.39	25.6	1.44							5.5	.32		
14	27.7	1.50	18.5	.94	21.4	1.10	23.6	1.24	25.4	1.35	26.6	1.42	27.4	1.48	27.6	1.50					5.9	.33	1.14	151
½	29.8	1.56	19.4	.95	22.5	1.11	24.9	1.25	26.9	1.38	28.3	1.45	29.1	1.51	29.7	1.55					6.3	.33		
15	31.8	1.61	20.1	.96	23.5	1.12	26.1	1.27	28.2	1.40	29.8	1.48	30.8	1.55	31.6	1.60	31.8	1.62			6.6	.34	1.15	156
½	34.0	1.67	21.0	.97	24.6	1.14	27.3	1.29	29.7	1.42	31.5	1.51	32.7	1.59	33.8	1.64	34.0	1.66			7.0	.34		
16	36.2	1.72	21.9	.97	25.6	1.15	28.7	1.30	31.3	1.44	33.1	1.54	34.6	1.63	35.6	1.68	36.1	1.71			7.4	.35	1.16	161
½	38.6	1.78	22.9	.98	26.7	1.16	30.0	1.31	32.8	1.46	34.9	1.56	36.5	1.66	37.6	1.72	38.2	1.76			7.8	.35		
17	40.9	1.83	23.6	.98	27.7	1.17	31.2	1.33	34.1	1.48	36.5	1.58	38.2	1.68	39.5	1.76	40.4	1.81	40.8	1.83	8.2	.36	1.17	165
18	45.8	1.93	25.4	.99	29.8	1.18	33.7	1.35	37.1	1.50	39.8	1.62	42.0	1.73	43.6	1.81	44.7	1.87	45.5	1.91	9.0	.37		
19	51.0	2.04	27.1	1.00	32.0	1.19	36.4	1.37	40.0	1.52	43.1	1.66	45.7	1.79	47.8	1.87	49.1	1.94	50.2	2.00	9.7	.38	1.18	169
20	56.6	2.15	28.7	1.01	34.2	1.21	38.8	1.39	43.0	1.55	46.5	1.70	49.5	1.83	51.7	1.92	53.6	2.00	55.0	2.08	10.5	.39		
21	62.4	2.26	30.5	1.01	36.4	1.22	41.5	1.41	46.1	1.59	49.9	1.73	53.2	1.86	56.0	1.97	58.1	2.06	59.9	2.14	11.3	.40	1.19	174
22	68.4	2.36	32.3	1.02	38.5	1.23	44.1	1.43	49.0	1.60	53.2	1.75	56.9	1.90	60.1	2.01	62.6	2.11	64.7	2.20	12.1	.40		
23	74.8	2.47	34.0	1.03	40.7	1.24	46.6	1.44	52.0	1.61	56.8	1.78	60.6	1.93	64.2	2.05	67.2	2.17	69.6	2.26	12.9	.41	1.20	179
24	81.4	2.58	35.8	1.04	42.9	1.25	49.2	1.46	55.0	1.64	60.1	1.81	64.5	1.96	68.5	2.09	71.9	2.23	74.6	2.32	13.6	.41		
26	95.6	2.79			47.1	1.27	54.5	1.48	61.0	1.67	66.9	1.85	72.3	2.00	77.0	2.16	81.0	2.29	84.5	2.40	15.2	.42	1.21	185
28	110.8	3.01			51.5	1.29	59.6	1.50	67.1	1.70	73.8	1.89	80.0	2.04	85.3	2.21	90.2	2.35	94.6	2.49	16.8	.43		
30	127.2	3.22			55.9	1.30	64.8	1.51	73.4	1.72	80.7	1.91	87.5	2.08	94.0	2.26	99.5	2.40	104.8	2.55	18.4	.44	1.22	191
32	144.8	3.44					70.1	1.53	79.1	1.74	87.6	1.94	95.2	2.12	102.5	2.30	109.0	2.45	114.7	2.61	20.0	.44		
34	163.4	3.65					75.2	1.54	85.1	1.76	94.6	1.96	103.0	2.15	111.2	2.34	118.5	2.50	125.0	2.66	21.5	.45	1.23	196
36	183.2	3.87					80.5	1.55	91.3	1.77	101.3	1.98	110.0	2.18	119.5	2.37	127.7	2.54	135.4	2.71	23.1	.45		
38	204.2	4.08									108.4	2.00	118.8	2.20	128.0	2.40	137.1	2.58	145.3	2.75	24.8	.46	1.24	201
40	226.2	4.30									115.2	2.01	126.5	2.22	137.0	2.43	146.6	2.61	155.6	2.79	26.4	.46		
42	249.4	4.51									122.0	2.02	134.1	2.24	145.4	2.46	156.2	2.64	166.1	2.82	27.9	.47	1.25	206
44	273.7	4.73													154.1	2.48	165.8	2.66	176.4	2.85	29.5	.47		
46	299.2	4.94													162.6	2.49	175.2	2.68	186.5	2.88	31.2	.47	1.26	212
48	325.8	5.16													171.5	2.50	184.5	2.71	197.7	2.91	32.8	.47		
50	353.5	5.37																	207.6	2.94	34.4	.48	1.27	219
52	382.3	5.59																	217.5	2.96	35.9	.48		
54	412.3	5.80																	228.2	2.98	37.5	.48	1.28	226
56	443.4	6.02																			39.1	.48		
58	475.6	6.23																			40.7	.48	1.29	233
60	509.0	6.45																			42.3	.49		
62	543.5	6.66																			43.7	.49	1.30	240
64	579.1	6.88																			45.6	.49		

M = Bending Moment, Kip ft. lbs. for balanced reinforcing.
M₁ = Moment in excess of M for beam size limited by conc.
Mc = Resist. Mom. Kip ft. lbs. of 1□″ compression steel
Aт = Sq. in. addn'l tensile steel for each 1□″ comp. steel.

UNIVERSAL BEAM TABLES

Rectangular Beams and Slabs with Balanced Reinforcing.
Rectangular Beams, Size Limited by Concrete Stress.
Tee Beams for Varying Slab Thickness.
Beams Reinforced for Compression.

$f_c = 1000$
$f_s = 18000$
$n = 12$

$f'_c = 2500$
$f_c = 0.40 f'_c$

MOMENTS IN KIP FOOT POUNDS AND STEEL AREAS PER FOOT WIDTH

EFF. DEPTH	Rectang. Beams		TEE BEAMS FOR SLAB THICKNESSES SHOWN																		COMPRESSION REINF.		RECTANG. BEAMS LIMITED BY CONCRETE	
			2″		2½″		3″		3½″		4″		4½″		5″		5½″		6″					
"d"	M	As	M	As	M	As	M	As	M	As	M	As	M	As	M	As	M	As	M	As	Mc	Aт	M₁/M	%As
1	.17	.13																						
½	.39	.20																					1.01	103
2	.69	.27																						
½	1.1	.33																					1.02	106
3	1.6	.40																						
½	2.1	.47																					1.03	110
4	2.8	.53																						
½	3.5	.60																					1.04	114
5	4.3	.67																						
½	5.2	.73																					1.05	117
6	6.2	.80	6.1	.78																	.6	.10		
½	7.3	.87	7.1	.83																	1.0	.14	1.06	121
7	8.5	.93	8.0	.86	8.4	.93															1.3	.18		
½	9.8	1.00	9.0	.89	9.6	.98															1.7	.21	1.07	125
8	11.1	1.07	9.9	.91	10.7	1.01	11.1	1.06													2.1	.23		
½	12.5	1.13	10.9	.94	11.9	1.05	12.5	1.11													2.5	.26	1.08	129
9	14.0	1.20	11.8	.96	13.0	1.08	13.8	1.16	14.0	1.20											2.9	.28		
½	15.6	1.27	12.8	.98	14.2	1.12	15.1	1.21	15.6	1.26											3.3	.30	1.09	133
10	17.3	1.33	13.7	1.00	15.4	1.15	16.5	1.25	17.1	1.31	17.4	1.34									3.7	.31		
½	19.1	1.40	14.6	1.01	16.6	1.18	17.9	1.29	18.8	1.36	19.1	1.40									4.1	.32	1.10	137
11	21.0	1.47	15.6	1.03	17.7	1.20	19.2	1.32	20.4	1.40	20.9	1.45	21.0	1.46							4.5	.33		
½	22.9	1.53	16.6	1.04	19.0	1.22	20.8	1.35	22.0	1.45	22.7	1.50	23.0	1.53							5.0	.35	1.11	141
12	25.0	1.60	17.5	1.05	20.1	1.24	22.1	1.38	23.5	1.49	24.5	1.55	24.9	1.59							5.4	.36		
½	27.1	1.67	18.5	1.06	21.4	1.25	23.6	1.40	25.2	1.53	26.4	1.60	26.9	1.65	27.0	1.67					5.8	.37	1.12	145
13	29.3	1.74	19.5	1.07	22.5	1.26	25.0	1.43	26.9	1.56	28.1	1.64	28.8	1.70	29.2	1.74					6.2	.38		
½	31.7	1.80	20.5	1.08	23.7	1.28	26.5	1.46	28.5	1.58	30.0	1.68	31.1	1.75	31.5	1.80					6.7	.39	1.13	150
14	34.0	1.87	21.5	1.09	25.0	1.30	27.9	1.48	30.1	1.60	31.8	1.71	33.3	1.80	33.7	1.85	34.0	1.86			7.1	.39		
½	36.5	1.93	22.5	1.10	26.2	1.31	29.5	1.50	31.7	1.62	33.6	1.75	35.2	1.84	36.0	1.90	36.5	1.92			7.6	.40	1.14	154
15	39.0	2.00	23.5	1.11	27.3	1.32	31.1	1.52	33.4	1.65	35.5	1.78	37.1	1.88	38.1	1.95	38.9	1.98	39.0	2.00	8.0	.41		
½	41.7	2.07	24.5	1.12	28.6	1.33	32.4	1.54	35.1	1.68	37.5	1.81	39.2	1.92	40.5	1.99	41.4	2.04	41.6	2.06	8.4	.41	1.15	159
16	44.4	2.14	25.4	1.13	29.9	1.34	33.6	1.56	36.7	1.70	39.4	1.84	41.4	1.95	42.7	2.03	43.8	2.09	44.2	2.12	8.8	.42		
½	47.3	2.20	26.4	1.13	31.1	1.35	35.1	1.58	38.5	1.72	41.3	1.86	43.5	1.99	45.1	2.07	46.3	2.14	47.0	2.18	9.3	.42	1.16	164
17	50.1	2.27	27.4	1.14	32.4	1.36	36.6	1.60	40.1	1.74	43.1	1.89	45.5	2.02	47.4	2.11	48.8	2.19	49.6	2.24	9.7	.43		
18	56.2	2.40	29.4	1.15	34.7	1.37	39.4	1.62	43.5	1.77	47.0	1.92	49.8	2.07	52.0	2.17	53.8	2.26	55.0	2.34	10.6	.44	1.17	169
19	62.6	2.53	31.4	1.16	37.2	1.39	42.4	1.63	46.8	1.80	50.8	1.96	54.0	2.11	56.7	2.24	58.9	2.33	60.5	2.42	11.5	.45		
20	69.3	2.67	33.4	1.16	39.8	1.40	45.4	1.64	50.4	1.82	54.7	2.00	58.4	2.16	61.5	2.29	64.0	2.40	66.0	2.50	12.4	.46	1.18	175
21	76.4	2.80	35.4	1.17	42.1	1.41	48.4	1.66	53.7	1.85	58.5	2.04	62.6	2.20	66.2	2.34	69.1	2.46	71.5	2.57	13.3	.47		
22	83.9	2.93	37.3	1.18	44.6	1.42	51.2	1.68	57.1	1.87	62.4	2.07	67.0	2.24	71.0	2.39	74.4	2.52	77.2	2.64	14.2	.47	1.19	181
23	91.7	3.07	39.3	1.19	47.1	1.43	54.2	1.69	60.6	1.89	66.4	2.09	71.5	2.27	75.9	2.43	79.6	2.57	82.7	2.70	15.1	.48		
24	99.8	3.20	41.3	1.20	49.6	1.44	57.1	1.70	64.0	1.91	70.1	2.11	75.8	2.30	80.6	2.46	84.9	2.61	88.5	2.75	16.0	.48	1.20	187
26	117.2	3.47			54.5	1.47	63.1	1.72	71.0	1.94	78.0	2.15	84.5	2.35	90.2	2.52	95.4	2.70	100.0	2.85	17.8	.49		
28	135.9	3.73			59.5	1.49	69.0	1.74	72.9	1.97	86.0	2.19	93.3	2.40	100.0	2.58	106.1	2.76	110.3	2.93	19.6	.50	1.21	193
30	156.0	4.00			64.5	1.50	75.0	1.75	84.7	1.99	93.7	2.22	102.1	2.44	109.6	2.64	115.5	2.82	122.9	3.00	21.4	.51		
32	177.5	4.27					81.0	1.76	91.6	2.01	101.7	2.25	111.0	2.47	119.5	2.69	127.5	2.87	134.6	3.06	23.2	.52	1.22	198
34	200.4	4.53					86.9	1.77	98.5	2.03	109.6	2.28	120.0	2.50	129.2	2.72	138.3	2.92	146.2	3.11	25.0	.52		
36	224.6	4.80					92.9	1.78	105.3	2.05	117.4	2.30	128.8	2.53	139.1	2.75	148.9	2.96	157.9	3.16	26.8	.53	1.23	204
38	250.3	5.07									125.4	2.32	137.9	2.56	149.0	2.78	159.7	3.00	169.6	3.21	28.7	.53		
40	277.3	5.33									133.4	2.34	146.7	2.58	159.0	2.81	170.5	3.04	181.6	3.25	30.3	.53	1.24	211
42	305.8	5.60									141.3	2.35	155.3	2.60	168.7	2.84	181.5	3.07	193.5	3.29	32.3	.54		
44	335.6	5.87													178.5	2.86	192.4	3.10	205.2	3.31	34.1	.54	1.25	218
46	366.8	6.13													188.3	2.88	203.0	3.12	217.0	3.34	36.0	.54		
48	399.4	6.40													198.6	2.90	213.9	3.14	229.0	3.37	37.8	.55	1.26	225
50	433.3	6.67																	240.4	3.40	39.6	.55		
52	468.7	6.93																	252.6	3.42	41.4	.55	1.27	232
54	505.4	7.20																	264.0	3.44	43.3	.56		
56	543.6	7.47																			45.1	.56	1.28	239
58	583.1	7.73																			46.9	.56		
60	624.0	8.00																			48.7	.56	1.29	248
62	666.3	8.27																			50.5	.56		
64	710.0	8.53																			52.4	.56	1.30	256

M = Bending Moment, Kip ft. lbs. for balanced reinforcing.
M_1 = Moment in excess of M for beam size limited by conc.
M_c = Resist. Mom. Kip ft. lbs. of 1 □″ compression steel
A_T = Sq. in. addn'l tensile steel for each 1 □″ comp. steel.

UNIVERSAL BEAM TABLES

Rectangular Beams and Slabs with Balanced Reinforcing.
Rectangular Beams, Size Limited by Concrete Stress.
Tee Beams for Varying Slab Thickness.
Beams Reinforced for Compression.

$f_c = 1125$
$f_s = 18000$
$n = 12$

$f'_c = 2500$
$f_c = 0.45 f'_c$

MOMENTS IN KIP FOOT POUNDS AND STEEL AREAS PER FOOT WIDTH

EFF. DEPTH	Rectang. Beams		TEE BEAMS FOR SLAB THICKNESSES SHOWN																		COMPRESSION REINF.	
			2″		2½″		3″		3½″		4″		4½″		5″		5½″		6″			
"d"	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M_c	A_T
1	.21	.16																				
½	.47	.24																				
2	.83	.32																				
½	1.3	.40																				
3	1.9	.48																				
½	2.5	.56																				
4	3.3	.64																				
½	4.2	.72																				
5	5.2	.80																				
½	6.3	.88																				
6	7.4	.96	7.1	.91	7.4	.96															.92	.15
½	8.7	1.04	8.2	.96	8.6	1.04															1.3	.19
7	10.1	1.13	9.3	1.00	9.9	1.10	10.1	1.13													1.7	.23
½	11.6	1.21	10.4	1.04	11.2	1.15	11.6	1.20													2.2	.26
8	13.2	1.29	11.4	1.06	12.5	1.19	13.1	1.26													2.6	.29
½	14.9	1.37	12.5	1.09	13.9	1.22	14.6	1.32	14.8	1.38											3.1	.31
9	16.7	1.45	13.5	1.11	15.1	1.26	16.1	1.37	16.6	1.44											3.5	.33
½	18.6	1.53	14.6	1.13	16.5	1.29	17.7	1.42	18.4	1.50	18.6	1.54									4.0	.35
10	20.7	1.61	15.7	1.15	17.8	1.32	19.3	1.46	20.1	1.55	20.6	1.60									4.4	.37
½	22.8	1.69	16.9	1.17	19.1	1.35	20.9	1.50	22.0	1.60	22.6	1.66	22.7	1.68							4.9	.39
11	25.0	1.77	17.9	1.19	20.5	1.38	22.4	1.54	23.7	1.65	24.6	1.72	25.0	1.76							5.4	.40
½	27.3	1.85	19.0	1.20	21.9	1.40	24.0	1.57	25.6	1.69	26.6	1.78	27.3	1.84							5.9	.41
12	29.8	1.93	20.1	1.21	23.1	1.42	25.6	1.60	27.4	1.73	28.6	1.84	29.4	1.90	29.8	1.93					6.3	.42
½	32.3	2.01	21.2	1.21	24.5	1.44	27.2	1.63	29.2	1.77	30.7	1.89	30.5	1.96	32.2	2.00					6.8	.43
13	34.9	2.09	22.3	1.22	25.9	1.46	28.9	1.65	31.1	1.80	32.8	1.93	34.0	2.01	34.6	2.06	35.0	2.09			7.3	.44
½	37.7	2.17	23.4	1.23	27.3	1.48	30.5	1.67	33.0	1.83	34.9	1.97	36.4	2.06	37.2	2.12	37.6	2.16			7.8	.45
14	40.5	2.25	24.5	1.24	28.6	1.49	32.1	1.69	34.9	1.86	37.0	2.00	38.7	2.11	39.7	2.19	40.2	2.24	40.1	2.25	8.3	.46
½	43.5	2.33	25.6	1.25	30.0	1.50	33.7	1.71	36.8	1.89	39.1	2.04	41.0	2.16	42.4	2.24	43.0	2.30	43.3	2.33	8.8	.46
15	46.5	2.41	26.7	1.26	31.4	1.51	35.4	1.73	38.6	1.91	41.3	2.07	43.2	2.20	44.9	2.29	45.7	2.36	46.4	2.40	9.2	.47
½	49.7	2.49	27.8	1.27	32.8	1.52	37.0	1.75	40.5	1.93	43.4	2.10	45.6	2.24	47.5	2.34	48.6	2.42	49.5	2.47	9.7	.48
16	52.9	2.57	29.0	1.28	34.1	1.53	38.6	1.77	42.4	1.95	45.5	2.13	48.0	2.27	50.0	2.38	51.4	2.47	52.4	2.54	10.2	.49
½	56.3	2.65	30.1	1.29	35.5	1.54	40.2	1.78	44.2	1.98	47.7	2.16	50.4	2.30	52.6	2.42	54.3	2.52	55.5	2.60	10.7	.49
17	59.7	2.73	31.2	1.30	36.9	1.56	41.9	1.80	46.1	2.00	49.9	2.20	52.7	2.34	55.1	2.46	57.1	2.56	58.5	2.65	11.2	.50
18	66.9	2.89	33.4	1.31	39.6	1.58	45.2	1.82	50.0	2.03	54.1	2.24	57.7	2.39	60.5	2.54	62.7	2.65	64.5	2.75	12.2	.51
19	74.6	3.05	35.6	1.32	42.5	1.59	48.5	1.84	53.8	2.06	58.5	2.27	62.5	2.44	65.8	2.60	68.5	2.74	70.7	2.84	13.2	.52
20	82.7	3.21	37.9	1.33	45.2	1.60	51.8	1.86	57.7	2.09	62.9	2.30	67.3	2.49	71.1	2.66	74.4	2.80	77.0	2.92	14.2	.53
21	91.1	3.38	40.1	1.34	48.0	1.62	55.1	1.88	61.5	2.11	67.3	2.33	72.2	2.54	76.5	2.71	80.1	2.86	83.4	3.00	15.2	.54
22	100.0	3.54	42.5	1.34	50.8	1.63	58.5	1.90	65.4	2.13	71.5	2.36	77.1	2.57	82.0	2.75	86.1	2.93	89.6	3.07	16.3	.54
23	109.3	3.70	44.5	1.35	53.6	1.64	61.8	1.92	69.2	2.15	76.0	2.39	82.1	2.60	87.3	2.80	92.0	2.98	96.0	3.13	17.3	.55
24	119.0	3.86	46.7	1.35	56.5	1.65	65.1	1.93	73.1	2.17	80.3	2.42	86.7	2.64	92.7	2.84	98.0	3.03	102.5	3.19	18.3	.55
26	139.7	4.18			61.5	1.67	71.7	1.94	80.8	2.20	89.1	2.46	96.8	2.70	103.7	2.90	109.9	3.11	115.1	3.28	20.3	.56
28	162.0	4.50			67.0	1.69	78.5	1.96	88.5	2.23	98.0	2.50	106.6	2.74	114.6	2.96	121.7	3.18	128.4	3.38	22.3	.57
30	186.0	4.82			72.7	1.70	85.1	1.98	96.5	2.26	106.2	2.53	116.7	2.78	125.5	3.02	133.9	3.25	141.4	3.45	24.4	.58
32	211.6	5.14					92.0	2.00	104.1	2.29	115.7	2.56	126.8	2.82	136.6	3.06	146.0	3.30	154.5	3.52	26.4	.59
34	238.9	5.46					98.5	2.02	112.0	2.31	124.9	2.59	136.6	2.86	147.5	3.10	157.8	3.35	167.6	3.58	28.5	.59
36	267.8	5.79					105.3	2.03	120.0	2.33	133.7	2.61	146.5	2.89	158.6	3.14	170.1	3.39	180.6	3.63	30.5	.60
38	298.4	6.11									143.0	2.63	157.0	2.92	169.8	3.17	182.2	3.43	194.0	3.68	32.6	.60
40	330.6	6.43									150.8	2.65	166.8	2.94	181.0	3.20	194.4	3.46	207.2	3.72	34.6	.61
42	364.5	6.75									160.5	2.67	176.7	2.96	193.0	3.23	206.7	3.50	220.3	3.76	36.7	.61
44	400.0	7.07													203.0	3.26	219.0	3.53	233.5	3.80	38.7	.61
46	437.2	7.39													214.5	3.28	231.3	3.56	247.1	3.83	40.8	.62
48	476.1	7.71													225.6	3.30	243.0	3.58	260.5	3.86	42.8	.62
50	516.6	8.04																	273.7	3.88	44.9	.62
52	558.7	8.36																	287.0	3.90	46.9	.63
54	602.5	8.68																	307.0	3.92	49.0	.63
56	648.0	9.00																			51.1	.63
58	695.1	9.32																			53.1	.63
60	743.9	9.64																			55.2	.63
62	794.3	9.96																			57.2	.64
64	846.4	10.29																			59.3	.64

RECTANG. BEAMS LIMITED BY CONCRETE	
M_1/M	%A_s
1.01	103
1.02	107
1.03	111
1.04	114
1.05	118
1.06	122
1.07	126
1.08	130
1.09	134
1.10	139
1.11	143
1.12	148
1.13	153
1.14	158
1.15	163
1.16	168
1.17	174
1.18	180
1.19	186
1.20	193
1.21	200
1.22	207
1.23	214
1.24	222
1.25	230
1.26	238
1.27	246
1.28	255
1.29	264
1.30	274

M = Bending Moment, Kip ft. lbs. for balanced reinforcing.
M_1 = Moment in excess of M for beam size limited by conc.
M_C = Resist. Mom. Kip ft. lbs. of 1□″ compression steel
A_T = Sq. in. addn'l tensile steel for each 1□″ comp. steel.

UNIVERSAL BEAM TABLES

Rectangular Beams and Slabs with Balanced Reinforcing.
Rectangular Beams, Size Limited by Concrete Stress.
Tee Beams for Varying Slab Thickness.
Beams Reinforced for Compression.

$f_c = 1050$
$f_s = 18000$
$n = 10$

$f'_c = 3000$
$f_c = 0.35 f'_c$

MOMENTS IN KIP FOOT POUNDS AND STEEL AREAS PER FOOT WIDTH

EFF. DEPTH	Rectang. Beams		TEE BEAMS FOR SLAB THICKNESSES SHOWN																		COMPRESSION REINF.	
			2″		2½″		3″		3½″		4″		4½″		5″		5½″		6″			
"d"	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M_c	A_T
1	.17	.13																				
½	.38	.19																				
2	.68	.26																				
½	1.1	.32																				
3	1.5	.39																				
½	2.1	.45																				
4	2.7	.52																				
½	3.4	.58																				
5	4.2	.64																				
½	5.1	.71																				
6	6.1	.77	6.2	.77																	.30	.05
½	7.2	.84	7.1	.81																	.60	.09
7	8.3	.90	8.0	.85	8.2	.90															.89	.12
½	9.5	.96	9.0	.89	9.4	.96															1.2	.15
8	10.9	1.03	9.9	.93	10.6	1.01															1.5	.17
½	12.3	1.10	11.0	.96	11.8	1.05	12.1	1.10													1.9	.19
9	13.7	1.16	12.0	.98	13.0	1.09	13.6	1.15													2.2	.21
½	15.3	1.22	12.9	1.00	14.4	1.12	15.0	1.20	15.4	1.23											2.6	.23
10	17.0	1.29	13.9	1.02	15.6	1.15	16.5	1.24	17.0	1.29											2.9	.24
½	18.7	1.35	15.0	1.04	16.8	1.18	18.0	1.28	18.6	1.35											3.3	.26
11	20.5	1.42	15.9	1.05	18.0	1.21	19.5	1.32	20.2	1.40	20.6	1.42									3.6	.27
½	22.4	1.48	17.0	1.07	19.2	1.23	21.0	1.35	21.9	1.45	22.5	1.47									4.0	.28
12	24.4	1.55	18.0	1.08	20.5	1.25	22.5	1.38	23.6	1.49	24.4	1.53									4.3	.29
½	26.5	1.61	19.1	1.10	21.9	1.27	24.0	1.41	25.4	1.53	26.3	1.59	26.4	1.62							4.7	.30
13	28.7	1.68	20.1	1.11	23.1	1.29	25.4	1.44	27.0	1.56	28.1	1.63	28.6	1.67							5.0	.31
½	31.0	1.75	21.1	1.12	24.3	1.31	26.9	1.46	28.8	1.59	30.0	1.67	30.8	1.72							5.4	.31
14	33.3	1.81	22.2	1.13	25.6	1.33	28.4	1.48	30.5	1.62	32.0	1.71	32.9	1.77	33.2	1.80					5.8	.32
½	35.8	1.87	23.3	1.14	27.0	1.34	29.9	1.50	32.3	1.65	33.9	1.75	35.0	1.81	35.7	1.86					6.2	.33
15	38.2	1.93	24.1	1.15	28.2	1.35	31.4	1.52	33.9	1.68	35.8	1.79	37.1	1.86	38.0	1.92	38.1	1.94			6.5	.33
½	40.8	2.00	25.2	1.16	29.6	1.36	32.9	1.54	35.7	1.71	37.8	1.82	39.3	1.90	40.5	1.97	40.8	2.00			6.9	.34
16	43.4	2.06	26.3	1.17	30.8	1.38	34.5	1.56	37.5	1.73	39.8	1.85	41.5	1.94	42.7	2.01	43.4	2.05			7.3	.35
½	46.2	2.13	27.5	1.18	32.1	1.40	36.0	1.58	39.3	1.75	41.8	1.88	43.7	1.98	45.3	2.05	45.9	2.10			7.7	.35
17	49.0	2.19	28.4	1.19	33.3	1.41	37.5	1.59	41.0	1.77	43.8	1.90	45.9	2.01	47.4	2.10	48.5	2.16	48.9	2.19	8.0	.36
18	55.0	2.32	30.4	1.20	35.7	1.43	40.5	1.62	44.5	1.81	47.7	1.95	50.4	2.08	52.4	2.17	53.8	2.25	54.6	2.30	8.8	.37
19	61.3	2.44	32.5	1.21	38.4	1.45	43.6	1.65	48.0	1.85	51.7	2.00	54.9	2.14	55.4	2.24	59.0	2.34	60.4	2.40	9.6	.38
20	67.9	2.58	34.5	1.22	41.1	1.46	46.6	1.67	51.6	1.88	55.7	2.04	59.4	2.19	62.0	2.31	64.4	2.42	66.0	2.49	10.3	.38
21	74.8	2.71	36.6	1.23	43.6	1.47	49.8	1.69	55.4	1.90	59.8	2.07	63.9	2.24	67.3	2.37	69.8	2.48	71.9	2.57	11.1	.39
22	82.1	2.84	38.7	1.24	46.0	1.48	53.0	1.71	58.8	1.92	64.0	2.11	68.3	2.28	72.1	2.42	75.1	2.54	77.8	2.64	11.9	.40
23	89.8	2.97	40.8	1.25	48.8	1.49	56.0	1.73	62.4	1.94	68.1	2.15	72.8	2.32	77.1	2.46	80.7	2.60	83.5	2.71	12.6	.40
24	97.7	3.09	42.9	1.26	51.5	1.50	59.1	1.75	66.0	1.96	72.2	2.18	77.5	2.36	82.2	2.50	86.3	2.66	89.5	2.77	13.4	.41
26	114.7	3.35			56.5	1.52	65.5	1.77	73.3	2.00	80.4	2.22	86.8	2.40	92.4	2.60	97.3	2.74	101.5	2.88	14.9	.42
28	133.0	3.61			61.7	1.54	71.6	1.79	80.6	2.03	88.7	2.26	96.0	2.45	102.5	2.66	108.2	2.82	113.7	2.98	16.5	.42
30	152.7	3.87			69.0	1.56	77.9	1.81	88.2	2.06	97.0	2.30	105.0	2.50	112.9	2.71	119.4	2.89	125.8	3.06	18.0	.43
32	173.7	4.13					84.2	1.83	95.0	2.09	105.1	2.33	114.3	2.55	123.0	2.76	130.7	2.95	137.9	3.14	19.6	.44
34	196.1	4.38					90.4	1.85	102.1	2.11	113.6	2.36	123.5	2.58	133.4	2.80	142.1	3.00	150.0	3.20	21.1	.44
36	219.9	4.64					96.5	1.86	109.5	2.13	121.8	2.38	133.2	2.61	143.5	2.84	153.4	3.05	162.5	3.26	22.8	.45
38	245.0	4.90									130.0	2.40	142.5	2.64	153.7	2.88	164.6	3.10	174.5	3.30	24.3	.45
40	271.5	5.16									136.9	2.41	151.9	2.67	164.4	2.91	176.0	3.14	186.9	3.34	25.8	.45
42	299.3	5.42									146.5	2.43	161.0	2.69	174.5	2.94	187.5	3.17	199.5	3.38	27.4	.46
44	328.5	5.67													185.0	2.96	199.0	3.20	211.8	3.42	29.0	.46
46	359.0	5.93													195.2	2.98	210.4	3.23	224.0	3.46	30.6	.46
48	390.9	6.19													206.0	3.00	221.4	3.25	236.8	3.50	32.2	.47
50	424.2	6.45																	249.2	3.53	33.7	.47
52	458.8	6.71																	261.0	3.55	35.2	.47
54	494.7	6.96																	274.0	3.57	36.8	.47
56	532.1	7.22																			38.4	.47
58	570.7	7.48																			40.0	.48
60	610.8	7.74																			41.5	.48
62	652.2	7.99																			43.0	.48
64	695.0	8.25																			44.6	.48

RECTANG. BEAMS LIMITED BY CONCRETE	
M_1/M	%A_s
1.01	103
1.02	106
1.03	109
1.04	112
1.05	116
1.06	120
1.07	124
1.08	127
1.09	130
1.10	134
1.11	138
1.12	142
1.13	146
1.14	151
1.15	156
1.16	161
1.17	165
1.18	169
1.19	174
1.20	179
1.21	185
1.22	191
1.23	196
1.24	201
1.25	206
1.26	212
1.27	219
1.28	226
1.29	233
1.30	240

M = Bending Moment, Kip ft. lbs. for balanced reinforcing.
M_1 = Moment in excess of M for beam size limited by conc.
M_c = Resist. Mom. Kip ft. lbs. of 1 □″ compression steel
A_T = Sq. in. addn'l tensile steel for each 1 □″ comp. steel.

UNIVERSAL BEAM TABLES

Rectangular Beams and Slabs with Balanced Reinforcing.
Rectangular Beams, Size Limited by Concrete Stress.
Tee Beams for Varying Slab Thickness.
Beams Reinforced for Compression.

$f_c = 1200$
$f_s = 18000$
$n = 10$

$f'_c = 3000$
$f_c = 0.40 f'_c$

MOMENTS IN KIP FOOT POUNDS AND STEEL AREAS PER FOOT WIDTH

EFF. DEPTH	Rectang. Beams		TEE BEAMS FOR SLAB THICKNESSES SHOWN																		COMPRESSION REINF.	
			2″		2½″		3″		3½″		4″		4½″		5″		5½″		6″			
"d"	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M_c	A_T
1	.21	.16																				
½	.47	.24																				
2	.83	.32																				
½	1.3	.40																				
3	1.9	.48																				
½	2.5	.56																				
4	3.3	.64																				
½	4.2	.72																				
5	5.2	.80																				
½	6.3	.88																				
6	7.5	.96	7.3	.93																	.6	.10
½	8.8	1.04	8.5	.99																	1.0	.14
7	10.2	1.12	9.6	1.04	10.0	1.11															1.3	.17
½	11.7	1.20	10.8	1.07	11.5	1.17															1.7	.20
8	13.3	1.28	11.9	1.10	12.9	1.22	13.3	1.27													2.0	.23
½	15.0	1.36	13.0	1.12	14.2	1.26	15.0	1.33													2.4	.25
9	16.8	1.44	14.1	1.15	15.6	1.30	16.5	1.39	16.8	1.44											2.8	.27
½	18.8	1.52	15.3	1.17	17.0	1.34	18.1	1.45	18.7	1.52											3.2	.29
10	20.8	1.60	16.3	1.19	18.4	1.38	19.8	1.50	20.6	1.58	20.8	1.60									3.6	.30
½	22.9	1.68	17.5	1.21	20.0	1.41	21.4	1.54	22.5	1.63	22.9	1.68									4.0	.32
11	25.2	1.76	18.7	1.23	21.4	1.43	23.1	1.58	24.4	1.68	25.0	1.74	25.2	1.76							4.4	.33
½	27.5	1.84	20.0	1.25	22.8	1.45	24.8	1.62	26.3	1.74	27.2	1.80	27.6	1.83							4.9	.34
12	30.0	1.92	21.0	1.27	24.2	1.48	26.5	1.65	28.2	1.79	29.4	1.86	29.8	1.90							5.3	.35
½	32.5	2.00	22.2	1.28	25.6	1.50	28.3	1.68	30.2	1.83	31.6	1.92	32.2	1.97	32.4	2.00					5.7	.36
13	35.2	2.08	23.4	1.29	27.0	1.52	30.0	1.71	32.2	1.86	33.8	1.97	34.6	2.04	35.1	2.08					6.1	.37
½	38.0	2.16	24.6	1.30	28.5	1.54	31.8	1.74	34.2	1.89	36.0	2.02	37.4	2.10	37.8	2.16					6.5	.38
14	40.8	2.24	25.8	1.31	30.0	1.56	33.4	1.77	36.2	1.92	38.2	2.06	39.9	2.16	40.5	2.22	40.8	2.23			6.9	.39
½	43.8	2.32	27.0	1.32	31.5	1.58	35.4	1.80	38.1	1.95	40.4	2.10	42.2	2.21	43.2	2.28	43.7	2.31			7.4	.39
15	46.8	2.40	28.2	1.33	32.8	1.59	37.3	1.83	40.1	1.98	42.6	2.13	44.5	2.25	45.7	2.34	46.6	2.38	46.8	2.40	7.8	.40
½	50.0	2.48	29.4	1.34	34.3	1.60	38.8	1.85	42.1	2.01	45.0	2.17	47.1	2.30	48.6	2.39	51.1	2.44	50.0	2.48	8.3	.40
16	53.2	2.56	30.5	1.35	35.8	1.61	40.3	1.87	44.1	2.04	47.2	2.20	49.6	2.34	51.3	2.44	52.5	2.50	53.1	2.55	8.7	.41
½	56.7	2.64	31.6	1.35	37.4	1.62	42.1	1.89	46.1	2.07	49.4	2.23	52.2	2.38	54.1	2.49	55.5	2.56	56.4	2.62	9.1	.41
17	60.1	2.72	32.8	1.36	38.9	1.63	43.9	1.91	48.1	2.09	51.6	2.27	54.6	2.41	56.8	2.54	58.5	2.62	59.5	2.69	9.5	.42
18	67.4	2.88	35.2	1.38	41.7	1.65	47.4	1.93	52.1	2.13	56.4	2.32	59.6	2.47	62.3	2.61	64.5	2.71	66.0	2.80	10.4	.43
19	75.1	3.04	37.6	1.39	44.7	1.67	50.8	1.95	56.3	2.16	60.8	2.36	64.9	2.54	68.1	2.68	70.6	2.80	72.6	2.90	11.3	.44
20	83.2	3.20	40.0	1.40	47.7	1.68	54.5	1.97	60.5	2.19	65.6	2.40	70.1	2.60	73.7	2.74	76.8	2.88	79.2	3.00	12.2	.45
21	91.7	3.36	42.5	1.41	50.5	1.70	58.0	1.99	64.5	2.22	70.2	2.44	75.1	2.65	79.5	2.80	82.9	2.95	85.8	3.09	13.0	.46
22	100.7	3.52	44.7	1.42	53.5	1.72	61.5	2.01	68.5	2.25	75.0	2.47	80.5	2.69	85.2	2.86	89.2	3.03	92.6	3.16	13.9	.46
23	110.0	3.68	47.1	1.43	56.5	1.73	65.1	2.03	72.7	2.27	79.5	2.50	85.6	2.73	91.0	2.91	95.6	3.09	99.3	3.23	14.8	.47
24	119.8	3.84	49.5	1.44	59.5	1.74	68.5	2.04	76.8	2.29	84.0	2.53	90.1	2.76	96.7	2.95	101.9	3.14	106.1	3.30	15.7	.47
26	140.6	4.16			65.5	1.77	75.7	2.05	85.2	2.32	93.5	2.58	101.4	2.82	108.3	3.03	114.5	3.24	120.0	3.42	17.5	.48
28	163.1	4.48			71.4	1.79	82.8	2.07	93.5	2.35	103.2	2.62	112.0	2.88	120.0	3.10	127.2	3.32	133.6	3.51	19.3	.49
30	187.2	4.80			77.4	1.80	90.0	2.09	101.6	2.38	112.5	2.66	122.6	2.93	131.7	3.16	140.0	3.39	147.5	3.60	21.0	.50
32	213.0	5.12					97.2	2.11	110.0	2.41	122.1	2.70	133.2	2.97	143.5	3.22	153.0	3.45	161.6	3.68	22.8	.51
34	240.4	5.44					104.1	2.13	118.0	2.43	131.7	2.73	143.9	3.00	155.1	3.26	169.0	3.51	175.6	3.74	24.6	.51
36	269.6	5.76					111.5	2.15	126.5	2.46	140.9	2.76	154.5	3.03	167.0	3.30	178.6	3.56	189.5	3.80	26.4	.52
38	300.4	6.08									150.5	2.78	165.4	3.06	179.0	3.34	191.7	3.60	203.6	3.85	28.2	.52
40	332.8	6.40									160.1	2.80	176.0	3.09	190.9	3.37	204.6	3.64	218.0	3.90	30.0	.53
42	366.9	6.72									169.6	2.82	186.3	3.12	202.4	3.40	217.9	3.68	232.0	3.94	31.7	.53
44	402.7	7.04													214.2	3.43	230.9	3.71	246.4	3.98	33.5	.53
46	440.1	7.36													226.0	3.46	243.9	3.74	260.1	4.02	35.3	.53
48	479.2	7.68													238.4	3.48	256.6	3.76	274.9	4.05	37.1	.54
50	520.0	8.00																	288.4	4.08	38.9	.54
52	562.4	8.32																	303.0	4.11	40.7	.54
54	606.5	8.64																	317.1	4.13	42.5	.54
56	652.3	8.96																			44.3	.55
58	699.7	9.28																			46.0	.55
60	748.8	9.60																			47.8	.55
62	799.6	9.92																			49.6	.55
64	852.0	10.24																			51.4	.55

RECTANG. BEAMS LIMITED BY CONCRETE	
M_1/M	$\%A_s$
1.01	103
1.02	106
1.03	110
1.04	114
1.05	117
1.06	121
1.07	125
1.08	129
1.09	133
1.10	137
1.11	141
1.12	145
1.13	150
1.14	154
1.15	159
1.16	164
1.17	169
1.18	175
1.19	181
1.20	187
1.21	193
1.22	198
1.23	204
1.24	211
1.25	218
1.26	225
1.27	232
1.28	239
1.29	248
1.30	256

M = Bending Moment, Kip ft. lbs. for balanced reinforcing.
M₁ = Moment in excess of M for beam size limited by conc.
Mc = Resist. Mom. Kip ft. lbs. of 1 □″ compression steel
Aт = Sq. in. addn'l tensile steel for each 1 □″ comp. steel.

UNIVERSAL BEAM TABLES

Rectangular Beams and Slabs with Balanced Reinforcing
Rectangular Beams, Size Limited by Concrete Stress.
Tee Beams for Varying Slab Thickness.
Beams Reinforced for Compression.

$f_c = 1350$
$f_s = 18000$
$n = 10$

$f'_c = 3000$
$f_c = 0.45\ f'_c$

MOMENTS IN KIP FOOT POUNDS AND STEEL AREAS PER FOOT WIDTH

EFF. DEPTH	Rectang. Beams		TEE BEAMS FOR SLAB THICKNESSES SHOWN																		COMPRESSION REINF.	
			2″		2½″		3″		3½″		4″		4½″		5″		5½″		6″			
"d"	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M_c	A_T
1	.25	.19																				
½	.56	.29																				
2	.99	.39																				
½	1.6	.48																				
3	2.2	.58																				
½	3.0	.68																				
4	4.0	.77																				
½	5.0	.87																				
5	6.2	.96																				
½	7.5	1.06																				
6	9.0	1.16	8.5	1.10	8.9	1.15															.9	.15
½	10.5	1.25	9.9	1.15	10.3	1.24															1.3	.19
7	12.2	1.35	11.1	1.20	11.8	1.32	12.1	1.36													1.7	.23
½	13.9	1.45	12.4	1.24	13.5	1.37	13.9	1.45													2.1	.26
8	15.9	1.54	13.6	1.27	15.0	1.42	15.7	1.52													2.5	.28
½	17.9	1.64	15.0	1.30	16.6	1.47	17.5	1.59	17.8	1.65											3.0	.31
9	20.1	1.74	16.2	1.33	18.2	1.51	19.3	1.65	19.9	1.73											3.4	.33
½	22.4	1.83	17.5	1.35	19.8	1.55	21.3	1.70	22.0	1.80	22.3	1.84									3.9	.35
10	24.8	1.93	18.9	1.38	21.3	1.59	23.1	1.75	24.1	1.86	24.7	1.92									4.3	.36
½	27.3	2.03	20.2	1.40	23.0	1.62	25.1	1.80	26.3	1.92	27.1	1.99	27.3	2.02							4.8	.38
11	30.0	2.12	21.4	1.42	24.6	1.65	26.8	1.84	28.5	1.98	29.5	2.07	30.0	2.11							5.3	.39
½	32.8	2.22	22.8	1.44	26.3	1.68	28.8	1.88	30.7	2.04	31.9	2.14	32.7	2.20							5.8	.40
12	35.7	2.31	24.1	1.45	27.7	1.70	30.8	1.92	32.8	2.09	34.3	2.20	35.2	2.28	35.7	2.31					6.2	.41
½	38.7	2.41	25.5	1.46	29.4	1.72	32.7	1.95	35.1	2.13	36.9	2.26	38.1	2.36	38.7	2.40					6.7	.42
13	41.9	2.51	26.7	1.47	31.0	1.74	34.7	1.98	37.3	2.16	39.2	2.31	40.8	2.42	41.5	2.47	43.5	2.50			7.1	.43
½	45.3	2.61	28.1	1.48	32.7	1.76	36.6	2.01	39.6	2.20	41.8	2.36	43.6	2.48	44.7	2.55	45.2	2.59			7.6	.44
14	48.6	2.70	29.4	1.49	34.4	1.78	38.6	2.04	41.9	2.23	44.4	2.40	46.3	2.54	47.6	2.62	48.3	2.68	48.5	2.70	8.1	.45
½	52.2	2.80	30.7	1.50	36.0	1.80	40.5	2.06	44.0	2.26	47.0	2.44	49.2	2.60	50.2	2.68	51.6	2.76	52.1	2.79	8.6	.46
15	55.8	2.89	32.1	1.51	37.6	1.82	42.5	2.08	46.4	2.29	49.5	2.47	51.9	2.65	53.9	2.74	54.9	2.84	55.7	2.88	9.1	.47
½	59.7	2.99	33.4	1.52	39.2	1.83	44.4	2.10	48.6	2.32	52.0	2.51	54.7	2.69	57.0	2.80	58.4	2.91	59.3	2.98	9.6	.47
16	63.5	3.09	34.8	1.53	41.0	1.84	46.4	2.12	50.9	2.35	54.5	2.55	57.5	2.73	60.0	2.86	61.7	2.97	62.9	3.05	10.0	.48
½	67.6	3.19	36.2	1.54	42.6	1.85	48.3	2.13	53.1	2.37	57.3	2.58	60.4	2.76	63.1	2.91	65.2	3.03	66.4	3.12	10.5	.48
17	71.7	3.28	37.4	1.55	44.2	1.86	50.3	2.14	55.4	2.40	59.8	2.61	63.3	2.80	66.2	2.96	68.4	3.08	70.1	3.18	11.0	.49
18	80.3	3.47	40.0	1.56	47.5	1.88	54.3	2.18	60.0	2.44	65.0	2.68	69.1	2.86	72.6	3.04	75.3	3.19	77.4	3.30	12.0	.50
19	89.5	3.66	42.7	1.58	51.0	1.90	58.2	2.21	64.5	2.47	70.3	2.72	74.9	2.92	78.9	3.12	82.2	3.28	84.8	3.41	13.0	.51
20	99.2	3.86	45.5	1.59	54.3	1.92	62.1	2.23	69.1	2.50	75.5	2.76	80.6	2.98	85.4	3.20	89.2	3.36	92.4	3.51	14.0	.52
21	109.4	4.05	48.1	1.60	57.6	1.94	66.1	2.25	73.7	2.53	80.6	2.80	86.5	3.04	91.8	3.25	96.2	3.44	100.0	3.60	15.0	.53
22	120.0	4.24	51.0	1.61	61.0	1.96	70.1	2.27	78.5	2.56	85.8	2.83	92.5	3.08	98.2	3.30	103.3	3.51	107.5	3.68	16.0	.53
23	131.2	4.44	53.4	1.62	64.4	1.97	74.0	2.29	83.0	2.59	91.1	2.86	98.4	3.12	104.6	3.35	110.3	3.57	115.0	3.75	17.0	.54
24	142 8	4.63	56.1	1.62	67.6	1.98	78.1	2.31	87.8	2.61	96.3	2.89	104.2	3.16	111.2	3.40	117.5	3.63	123.0	3.82	18.0	.54
26	167.6	5.01			73.7	2.01	86.1	2.34	97.0	2.65	107.0	2.96	116.1	3.24	124.4	3.50	131.6	3.74	138.3	3.94	20.0	.55
28	194.4	5.40			80.4	2.03	94.1	2.36	106.4	2.68	117.6	3.00	128.0	3.29	137.5	3.57	146.1	3.82	154.1	4.05	22.0	.56
30	223.2	5.79			87.2	2.04	102.1	2.38	115.6	2.71	128.2	3.04	140.0	3.34	150.6	3.63	162.2	3.90	169.7	4.14	24.0	.57
32	253.9	6.17					110.2	2.40	125.0	2.74	138.8	3.08	152.0	3.39	164.0	3.68	175.1	3.96	185.3	4.21	26.0	.58
34	286.7	6.56					118.2	2.42	134.4	2.77	149.7	3.10	163.7	3.42	177.0	3.72	189.5	4.02	201.1	4.30	28.0	.58
36	321.4	6.94					126.3	2.43	143.9	2.79	160.4	3.13	175.9	3.45	190.4	3.76	204.2	4.07	216.8	4.35	30.0	.59
38	358.1	7.33									171.2	3.16	188.1	3.48	203.8	3.80	218.6	4.11	233.0	4.40	32.0	.59
40	396.7	7.71									182.0	3.18	200.0	3.52	217.1	3.84	233.3	4.15	248.9	4.45	34.0	.60
42	437.4	8.10									191.2	3.20	212.0	3.54	230.0	3.87	248.0	4.20	264.5	4.50	36.0	.60
44	480.1	8.49													243.8	3.90	262.8	4.23	280.2	4.54	38.0	.60
46	524.7	8.87													257.6	3.93	277.9	4.26	296.7	4.58	40.0	.61
48	571.3	9.26													270.9	3.96	291.9	4.29	312.8	4.62	42.0	.61
50	619.9	9.64																	328.5	4.65	44.0	.61
52	670.5	10.03																	344.5	4.68	46.0	.62
54	723.1	10.41																	368.4	4.70	48.0	.62
56	777.6	10.80																			50.0	.62
58	834.2	11.19																			52.0	.62
60	892.7	11.57																			54.0	.62
62	953.2	11.96																			56.0	.63
64	1016.	12.34																			58.0	.63

RECTANG. BEAMS LIMITED BY CONCRETE	
M_1/M	%A_s
1.01	103
1.02	107
1.03	111
1.04	114
1.05	118
1.06	122
1.07	126
1.08	130
1.09	134
1.10	139
1.11	143
1.12	148
1.13	153
1.14	158
1.15	163
1.16	168
1.17	174
1.18	180
1.19	186
1.20	193
1.21	200
1.22	207
1.23	214
1.24	222
1.25	230
1.26	238
1.27	246
1.28	255
1.29	264
1.30	274

M = Bending Moment, Kip ft. lbs. for balanced reinforcing.
M_1 = Moment in excess of M for beam size limited by conc.
M_c = Resist. Mom. Kip ft. lbs. of 1□″ compression steel
A_T = Sq. in. addn'l tensile steel for each 1□″ comp. steel.

UNIVERSAL BEAM TABLES

Rectangular Beams and Slabs with Balanced Reinforcing.
Rectangular Beams, Size Limited by Concrete Stress.
Tee Beams for Varying Slab Thickness.
Beams Reinforced for Compression.

$f_c = 700$
$f_s = 20000$
$n = 15$

$f'_c = 2000$
$f_c = 0.35 f'_c$

MOMENTS IN KIP FOOT POUNDS AND STEEL AREAS PER FOOT WIDTH

EFF. DEPTH	Rectang. Beams		TEE BEAMS FOR SLAB THICKNESSES SHOWN																		COMPRESSION REINF.	
			2″		2½″		3″		3½″		4″		4½″		5″		5½″		6″			
"d"	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M_c	A_T
1	.11	.07																				
½	.24	.11																				
2	.43	.14																				
½	.67	.18																				
3	.96	.22																				
½	1.3	.25																				
4	1.7	.29																				
½	2.2	.33																				
5	2.7	.36																				
½	3.2	.40																				
6	3.8	.43	3,8	.43																	.10	.02
½	4.5	.47	4.5	.46																	.40	.05
7	5.2	.51	5.1	.49																	.69	.08
½	6.0	.54	5.8	.52																	1.0	.11
8	6.8	.58	6.4	.54	6.8	.57															1.3	.14
½	7.7	.61	7.1	.56	7.6	.60															1.7	.16
9	8.6	.65	7.7	.57	8.4	.63	8.6	.65													2.0	.17
½	9.6	.69	8.4	.58	9.2	.65	9.6	.68													2.4	.19
10	10.7	.72	9.1	.60	10.0	.67	10.5	.71													2.7	.21
½	11.8	.76	9.7	.61	10.9	.69	11.5	.74													3.1	.22
11	12.9	.80	10.3	.62	11.7	.70	12.5	.76	12.8	.79											3.5	.23
½	14.1	.83	11.1	.63	12.5	.72	13.5	.78	13.0	.82											3.8	.24
12	15.4	.87	11.8	.64	13.3	.73	14.4	.80	15.1	.85	15.4	.87									4.2	.25
½	16.7	.90	12.5	.65	14.2	.75	15.4	.82	16.2	.88	16.6	.90									4.6	.26
13	18.0	.94	13.2	.65	15.0	.76	16.4	.84	17.4	.90	17.9	.93									5.0	.27
½	19.5	.98	13.8	.66	15.9	.77	17.4	.86	18.5	.92	19.2	.96									5.4	.28
14	20.9	1.01	14.5	.67	16.7	.78	18.4	.87	19.6	.94	20.4	.98	20.9	1.01							5.7	.29
½	24.5	1.05	15.2	.68	17.6	.79	19.4	.88	20.8	.96	21.7	1.01	22.3	1.04							6.1	.30
15	24.0	1.08	15.9	.68	18.4	.80	20.4	.89	21.9	.97	23.0	1.03	23.7	1.07	24.0	1.08					6.5	.30
½	25.7	1.12	16.6	.69	19.3	.81	21.4	.91	23.1	.99	24.3	1.05	25.2	1.10	25.6	1.12					6.9	.31
16	27.3	1.16	17.3	.69	20.2	.81	22.4	.92	24.3	1.00	25.6	1.07	26.6	1.12	27.1	1.15	27.3	1.16			7.3	.31
½	29.1	1.20	18.0	.70	21.0	.82	23.5	.93	25.5	1.02	27.0	1.09	28.1	1.14	28.7	1.18	29.0	1.19			7.7	.32
17	30.8	1.23	18.7	.70	21.8	.83	24.5	.94	26.6	1.03	28.3	1.11	29.5	1.16	30.3	1.20	30.7	1.22			8.1	.32
18	34.6	1.30	20.0	.70	23.5	.84	26.5	.96	29.0	1.05	31.0	1.14	32.5	1.20	33.6	1.25	34.2	1.28	34.5	1.30	8.9	.33
19	38.5	1.37	21.4	.71	25.3	.85	28.5	.97	31.4	1.08	33.6	1.17	35.4	1.24	36.8	1.30	37.7	1.34	38.3	1.36	9.6	.34
20	42.7	1.45	22.8	.72	27.0	.86	30.6	.99	33.7	1.10	36.3	1.19	38.4	1.27	40.2	1.34	41.3	1.39	42.1	1.42	10.4	.35
21	47.0	1.52	24.2	.72	28.7	.87	32.7	1.00	36.1	1.11	38.9	1.21	41.5	1.30	43.4	1.37	44.9	1.43	46.0	1.47	11.2	.35
22	51.6	1.59	25.6	.73	30.4	.88	34.7	1.01	38.5	1.13	41.7	1.24	44.5	1.33	46.7	1.41	48.5	1.47	49.9	1.52	12.0	.36
23	56.4	1.66	27.0	.73	32.2	.88	36.8	1.02	40.9	1.15	44.5	1.26	47.5	1.35	50.0	1.44	52.1	1.51	53.8	1.57	12.8	.37
24	61.4	1.74	28.4	.74	33.9	.89	38.9	1.03	43.3	1.16	47.2	1.27	50.6	1.38	53.5	1.47	55.8	1.54	57.7	1.61	13.6	.37
26	72.1	1.88			37.4	.90	43.0	1.05	48.1	1.18	52.6	1.30	56.7	1.42	60.1	1.51	63.1	1.60	65.7	1.68	15.2	.38
28	83.6	2.02			40.9	.91	47.2	1.06	52.9	1.20	58.1	1.33	62.7	1.45	66.9	1.56	70.5	1.65	73.6	1.74	16.8	.39
30	96.0	2.17			44.4	.92	51.4	1.07	57.6	1.22	63.6	1.35	69.0	1.48	73.7	1.59	77.9	1.69	81.7	1.79	18.4	.40
32	109.2	2.31					55.5	1.09	62.6	1.24	69.1	1.37	75.2	1.51	80.5	1.62	85.4	1.73	89.8	1.83	20.1	.40
34	123.3	2.46					59.7	1.10	67.4	1.25	74.8	1.40	81.3	1.53	87.3	1.65	92.9	1.77	97.9	1.87	21.7	.41
36	138.2	2.60					63.8	1.11	72.3	1.26	80.2	1.41	87.4	1.55	94.2	1.68	100.0	1.80	106.1	1.91	23.3	.41
38	154.0	2.75									85.7	1.42	93.6	1.56	101.2	1.70	107.6	1.82	114.3	1.94	24.9	.42
40	170.7	2.89									91.2	1.44	99.9	1.58	108.0	1.72	115.0	1.85	122.4	1.97	26.5	.42
42	188.2	3.04									96.7	1.45	106.0	1.60	115.0	1.74	122.5	1.87	130.8	2.00	28.2	.42
44	206.5	3.18													121.7	1.75	130.6	1.89	139.2	2.02	29.8	.43
46	225.7	3.33													128.5	1.77	138.3	1.91	147.4	2.04	31.4	.43
48	245.8	3.47													135.9	1.79	145.9	1.93	155.2	2.06	33.0	.43
50	266.7	3.61																	163.8	2.08	34.6	.43
52	288.4	3.76																	172.0	2.10	36.3	.44
54	311.0	3.90																	180.2	2.11	37.9	.44
56	334.5	4.05																			39.5	.44
58	358.8	4.19																			41.2	.44
60	384.0	4.34																			42.8	.44
62	410.0	4.48																			44.4	.44
64	436.9	4.63																			46.0	.44

RECTANG. BEAMS LIMITED BY CONCRETE	
M_1/M	%A_s
1.01	103
1.02	105
1.03	108
1.04	111
1.05	114
1.06	119
1.07	122
1.08	125
1.09	129
1.10	132
1.11	136
1.12	140
1.13	144
1.14	148
1.15	152
1.16	156
1.17	160
1.18	165
1.19	170
1.20	175
1.21	180
1.22	185
1.23	191
1.24	196
1.25	201
1.26	206
1.27	211
1.28	217
1.29	223
1.30	230

M = Bending Moment, Kip ft. lbs. for balanced reinforcing.
M_1 = Moment in excess of M for beam size limited by conc.
M_c = Resist. Mom. Kip ft. lbs. of 1□″ compression steel
A_T = Sq. in. addn'l tensile steel for each 1□″ comp. steel.

UNIVERSAL BEAM TABLES

Rectangular Beams and Slabs with Balanced Reinforcing.
Rectangular Beams, Size Limited by Concrete Stress.
Tee Beams for Varying Slab Thickness.
Beams Reinforced for Compression.

$f_c = 800$
$f_s = 20000$
$n = 15$

$f'_c = 2000$
$f_c = 0.40 f'_c$

MOMENTS IN KIP FOOT POUNDS AND STEEL AREAS PER FOOT WIDTH

EFF. DEPTH	Rectang. Beams		TEE BEAMS FOR SLAB THICKNESSES SHOWN																		COMPRESSION REINF.		RECTANG. BEAMS LIMITED BY CONCRETE	
			2″		2½″		3″		3½″		4″		4½″		5″		5½″		6″					
"d"	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M_c	A_T	M_1/M	%A_s
1	.13	.09																						
½	.30	.14																					1.01	103
2	.53	.18																						
½	.82	.23																					1.02	106
3	1.2	.27																						
½	1.6	.32																					1.03	109
4	2.1	.36																						
½	2.7	.41																					1.04	112
5	3.3	.45																						
½	4.0	.50																					1.05	116
6	4.7	.54	4.7	.53																	.41	.06		
½	5.5	.59	5.5	.57																	.76	.10	1.06	120
7	6.4	.63	6.3	.61	6.4	.63															1.1	.13		
½	7.4	.68	7.0	.63	7.2	.67															1.5	.16	1.07	124
8	8.4	.72	7.7	.64	8.2	.70	8.4	.72													1.9	.19		
½	9.5	.77	8.4	.66	9.2	.73	9.5	.76													2.3	.21	1.08	127
9	10.6	.81	9.2	.68	10.1	.76	10.5	.80													2.7	.23		
½	11.8	.86	9.9	.69	11.0	.78	11.6	.83													3.1	.25	1.09	131
10	13.1	.90	10.7	.70	11.9	.80	12.7	.86	13.1	.90											3.5	.26		
½	14.5	.95	11.5	.72	12.9	.82	13.8	.89	14.4	.94											3.9	.28	1.10	135
11	15.9	.99	12.3	.73	13.8	.84	15.0	.92	15.6	.97	15.9	.99									4.3	.29		
½	17.4	1.04	13.0	.74	14.8	.86	16.1	.94	16.9	1.00	17.3	1.03									4.8	.30	1.11	139
12	18.9	1.08	13.8	.75	15.8	.87	17.2	.96	18.2	1.03	18.7	1.07	18.9	1.08							5.2	.31		
½	20.5	1.13	14.6	.76	16.7	.88	18.3	.98	19.5	1.06	20.2	1.10	20.5	1.12							5.7	.32	1.12	143
13	22.2	1.17	15.4	.76	17.7	.89	19.5	1.00	20.8	1.08	21.6	1.13	22.1	1.16							6.1	.33		
½	24.0	1.22	16.2	.77	18.7	.90	20.6	1.02	22.1	1.10	23.1	1.16	23.7	1.20							6.5	.34	1.13	147
14	25.7	1.26	16.9	.78	19.6	.91	21.8	1.03	23.4	1.12	24.6	1.19	25.3	1.23	25.7	1.26					6.9	.35		
½	27.6	1.31	17.7	.79	20.6	.92	22.9	1.05	24.8	1.14	26.1	1.22	27.0	1.27	27.5	1.30					7.4	.36	1.14	151
15	29.5	1.35	18.5	.79	21.6	.93	24.1	1.06	26.1	1.16	27.6	1.24	28.6	1.30	29.3	1.33	29.5	1.35			7.8	.36		
½	31.6	1.40	19.3	.80	22.6	.94	25.2	1.07	27.4	1.18	29.1	1.26	30.3	1.33	31.1	1.37	31.5	1.39			8.3	.37	1.15	156
16	33.6	1.44	20.1	.80	23.5	.95	26.4	1.08	28.8	1.19	30.6	1.28	31.9	1.35	32.9	1.40	33.4	1.43	33.6	1.44	8.7	.37		
½	35.8	1.49	20.9	.81	24.5	.96	27.6	1.09	30.1	1.21	32.1	1.30	33.6	1.38	34.7	1.43	35.4	1.47	35.7	1.48	9.2	.38	1.16	160
17	37.9	1.53	21.7	.81	25.5	.97	28.7	1.10	31.5	1.22	33.6	1.32	35.3	1.40	36.6	1.46	37.4	1.50	37.8	1.52	9.6	.38		
18	42.5	1.62	23.3	.82	27.5	.98	31.1	1.12	34.1	1.24	36.6	1.35	38.7	1.44	40.3	1.51	41.4	1.56	42.2	1.60	10.5	.39	1.17	165
19	47.4	1.71	24.8	.83	29.4	.99	33.4	1.14	36.9	1.27	39.8	1.38	42.1	1.48	44.0	1.56	45.5	1.62	46.5	1.67	11.4	.40		
20	52.5	1.80	26.4	.83	31.4	1.00	35.8	1.15	39.6	1.29	42.8	1.41	45.5	1.51	47.8	1.60	49.6	1.67	50.9	1.73	12.3	.41	1.18	170
21	57.9	1.89	28.0	.84	33.4	1.01	38.1	1.17	42.3	1.31	45.9	1.43	49.0	1.54	51.6	1.64	53.7	1.72	55.4	1.78	13.2	.42		
22	63.5	1.98	29.6	.84	35.4	1.02	40.5	1.18	45.0	1.32	49.0	1.45	52.4	1.57	55.3	1.67	57.8	1.76	59.8	1.83	14.1	.42	1.19	175
23	69.4	2.07	31.2	.85	37.3	1.03	42.8	1.19	47.7	1.34	52.1	1.47	56.0	1.60	59.2	1.71	61.9	1.80	64.3	1.88	15.1	.43		
24	75.6	2.16	32.8	.86	39.3	1.04	45.2	1.20	50.5	1.35	55.3	1.49	59.5	1.62	63.1	1.73	66.2	1.83	68.8	1.92	16.0	.44	1.20	181
26	88.7	2.34			43.3	1.05	50.0	1.22	56.0	1.38	61.5	1.53	66.5	1.66	70.8	1.78	74.5	1.89	77.9	1.99	17.8	.45		
28	102.9	2.52			47.3	1.06	54.7	1.23	61.6	1.40	67.8	1.56	73.4	1.70	78.5	1.83	83.1	1.95	81.1	2.06	19.6	.45	1.21	186
30	118.1	2.70			51.2	1.07	59.5	1.24	67.0	1.42	74.0	1.58	80.5	1.73	86.4	1.87	91.6	1.99	96.4	2.11	21.5	.46		
32	134.4	2.88					64.2	1.26	72.7	1.44	80.4	1.60	87.5	1.75	94.2	1.90	100.1	2.04	105.7	2.16	23.3	.47	1.22	192
34	151.7	3.06					68.9	1.27	78.1	1.45	86.7	1.62	94.6	1.78	102.0	1.93	108.8	2.07	115.0	2.20	25.2	.47		
36	170.1	3.24					73.7	1.28	83.6	1.46	93.1	1.64	101.8	1.80	109.9	1.96	117.4	2.10	124.4	2.24	27.1	.48	1.23	198
38	189.5	3.42									99.3	1.65	108.8	1.82	117.7	1.98	125.9	2.13	133.8	2.28	28.9	.48		
40	210.0	3.60									105.8	1.67	116.1	1.84	125.7	2.00	134.5	2.16	143.0	2.30	30.7	.49	1.24	204
42	231.5	3.78									111.8	1.67	122.9	1.85	133.3	2.02	143.1	2.18	152.6	2.33	32.6	.49		
44	254.1	3.96													141.5	2.04	152.0	2.20	161.8	2.35	34.4	.49	1.25	210
46	277.7	4.14													149.4	2.05	160.6	2.22	171.3	2.38	36.3	.50		
48	302.4	4.32													157.3	2.07	169.2	2.23	181.0	2.40	38.2	.50	1.26	216
50	328.1	4.50																	190.2	2.42	40.0	.50	1.27	222
52	354.9	4.68																	200.0	2.44	41.9	.50		
54	382.7	4.86																	209.5	2.46	43.7	.50		
56	411.6	5.04																			45.6	.51	1.28	229
58	441.5	5.22																			47.5	.51	1.29	236
60	472.5	5.40																			49.3	.51		
62	504.5	5.58																			51.1	.51	1.30	244
64	537.6	5.76																			52.9	.51		

M = Bending Moment, Kip ft. lbs. for balanced reinforcing.
M_1 = Moment in excess of M for beam size limited by conc.
M_c = Resist. Mom. Kip ft. lbs. of 1□″ compression steel
A_T = Sq. in. addn'l tensile steel for each 1□″ comp. steel.

UNIVERSAL BEAM TABLES

Rectangular Beams and Slabs with Balanced Reinforcing.
Rectangular Beams, Size Limited by Concrete Stress.
Tee Beams for Varying Slab Thickness.
Beams Reinforced for Compression.

$f_c = 900$
$f_s = 20000$
$n = 15$

$f'_c = 2000$
$f_c = 0.45 f'_c$

MOMENTS IN KIP FOOT POUNDS AND STEEL AREAS PER FOOT WIDTH

EFF. DEPTH	Rectang. Beams		TEE BEAMS FOR SLAB THICKNESSES SHOWN																		COMPRESSION REINF.	
			2″		2½″		3″		3½″		4″		4½″		5″		5½″		6″			
"d"	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M_c	A_T
1	.16	.11																				
½	.35	.16																				
2	.63	.22																				
½	.98	.27																				
3	1.4	.33																				
½	1.9	.38																				
4	2.5	.44																				
½	3.2	.49																				
5	3.9	.54																				
½	4.7	.60																				
6	5.7	.65	5.5	.63																	.73	.11
½	6.6	.71	6.4	.67																	1.1	.15
7	7.7	.76	7.2	.70	7.6	.75															1.5	.18
½	8.8	.82	8.0	.72	8.6	.79															2.0	.21
8	10.0	.87	8.9	.74	9.7	.83	9.9	.87													2.4	.24
½	11.3	.92	9.7	.76	10.2	.86	11.2	.91													2.9	.26
9	12.7	.98	10.6	.78	11.8	.88	12.4	.95													3.3	.28
½	14.2	1.03	11.5	.80	12.8	.91	13.7	.99													3.8	.30
10	15.7	1.09	12.3	.81	13.9	.93	14.9	1.02	15.5	1.07	15.7	1.09									4.2	.32
½	17.3	1.14	13.2	.83	15.0	.95	16.2	1.05	16.9	1.11	17.3	1.14									4.7	.34
11	19.0	1.20	14.1	.84	16.0	.97	17.4	1.07	18.4	1.14	18.9	1.19									5.2	.35
½	20.8	1.25	15.0	.85	17.1	.99	18.7	1.10	19.8	1.18	20.5	1.23									5.7	.36
12	22.6	1.31	15.8	.86	18.2	1.00	20.0	1.12	21.3	1.21	22.1	1.27	22.5	1.30							6.2	.37
½	24.5	1.36	16.7	.86	19.3	1.02	21.3	1.14	22.8	1.24	23.8	1.31	24.3	1.35							6.7	.38
13	26.5	1.41	17.6	.87	20.4	1.03	22.6	1.16	24.2	1.26	25.4	1.34	26.2	1.39	26.5	1.41					7.1	.39
½	28.7	1.47	18.5	.88	21.4	1.04	23.9	1.18	25.7	1.28	27.1	1.37	28.0	1.43	28.5	1.46					7.6	.40
14	30.8	1.52	19.4	.89	22.5	1.05	25.1	1.19	27.2	1.30	28.7	1.39	29.8	1.46	30.5	1.50	30.8	1.52			8.1	.41
½	33.1	1.58	20.2	.89	23.6	1.06	26.4	1.21	28.7	1.32	30.4	1.42	31.7	1.50	32.5	1.54	32.9	1.57			8.6	.42
15	35.3	1.63	21.1	.90	24.7	1.07	27.7	1.22	30.2	1.34	32.1	1.45	33.6	1.53	34.6	1.58	35.1	1.62	35.3	1.63	9.1	.42
½	37.8	1.69	22.0	.90	25.8	1.08	29.1	1.23	31.7	1.36	33.8	1.47	35.5	1.56	36.6	1.62	37.3	1.66	37.7	1.68	9.6	.43
16	40.2	1.74	22.9	.91	26.9	1.09	30.4	1.24	33.2	1.38	35.5	1.49	37.3	1.58	38.7	1.65	39.5	1.70	40.0	1.73	10.1	.43
½	42.8	1.80	23.8	.91	28.1	1.10	31.7	1.26	34.7	1.40	37.2	1.51	39.2	1.61	40.7	1.69	41.8	1.74	42.5	1.78	10.7	.44
17	45.4	1.85	24.7	.92	29.2	1.11	33.0	1.27	36.3	1.41	39.0	1.53	41.1	1.63	42.8	1.72	44.0	1.78	44.8	1.82	11.2	.45
18	50.9	1.96	26.5	.93	31.4	1.12	35.6	1.29	39.3	1.43	42.4	1.56	44.9	1.68	47.0	1.77	48.6	1.84	49.8	1.90	12.2	.46
19	56.7	2.07	28.3	.94	33.6	1.13	38.3	1.30	42.3	1.46	45.9	1.60	48.8	1.72	51.3	1.82	53.2	1.90	54.7	1.97	13.2	.47
20	62.8	2.18	30.0	.95	35.8	1.14	40.9	1.32	45.4	1.48	49.3	1.62	52.7	1.75	55.5	1.86	57.8	1.96	59.7	2.04	14.2	.47
21	69.2	2.28	31.8	.95	38.0	1.15	43.6	1.33	48.5	1.50	52.8	1.65	56.6	1.78	59.8	1.90	62.5	2.01	64.7	2.09	15.2	.48
22	76.0	2.39	33.6	.96	40.3	1.16	46.2	1.35	51.6	1.52	56.3	1.67	60.5	1.81	64.0	1.94	67.1	2.05	69.7	2.14	16.3	.49
23	83.0	2.50	35.4	.96	42.5	1.17	48.9	1.36	54.7	1.53	59.8	1.69	64.4	1.84	68.3	1.97	71.9	2.09	74.8	2.19	17.3	.49
24	90.4	2.61	37.2	.97	44.7	1.18	51.5	1.37	57.7	1.55	63.3	1.71	68.3	1.86	72.7	2.00	76.6	2.13	79.9	2.23	18.3	.50
26	106.1	2.83			49.2	1.19	56.9	1.39	64.0	1.58	70.4	1.75	76.2	1.91	81.4	2.06	86.1	2.19	90.2	2.31	20.4	.51
28	123.1	3.05			53.7	1.20	62.2	1.40	70.1	1.60	77.5	1.78	84.1	1.95	90.2	2.10	95.6	2.24	100.6	2.38	22.5	.52
30	141.3	3.26			58.2	1.21	67.6	1.42	76.4	1.62	84.6	1.80	92.0	1.98	99.0	2.14	105.2	2.29	111.0	2.44	24.5	.53
32	160.8	3.48					73.0	1.43	82.5	1.63	91.6	1.82	99.9	2.00	107.8	2.18	115.0	2.34	121.3	2.48	26.6	.53
34	181.5	3.70					78.3	1.44	88.8	1.65	98.7	1.84	108.0	2.03	116.6	2.21	124.6	2.37	131.9	2.53	28.7	.54
36	203.5	3.92					83.6	1.45	95.2	1.66	105.8	1.86	115.9	2.05	125.4	2.23	134.2	2.41	142.5	2.57	30.8	.54
38	226.7	4.13									113.0	1.88	124.1	2.07	134.2	2.26	143.9	2.44	152.9	2.60	32.9	.55
40	251.2	4.35									120.1	1.89	132.1	2.09	143.1	2.28	153.7	2.46	163.5	2.64	34.9	.55
42	276.9	4.57									127.3	1.91	140.0	2.11	151.9	2.30	163.3	2.48	174.3	2.67	37.0	.56
44	303.9	4.79													160.9	2.32	173.1	2.51	184.9	2.69	39.1	.56
46	332.2	5.00													169.8	2.33	182.9	2.53	195.5	2.72	41.2	.56
48	361.7	5.22													178.7	2.35	192.7	2.55	206.0	2.74	43.3	.56
50	392.5	5.44																	217.0	2.76	45.4	.57
52	424.5	5.66																	227.5	2.78	47.5	.57
54	457.8	5.88																	238.1	2.79	49.6	.57
56	492.3	6.09																			51.7	.57
58	528.1	6.31																			53.8	.58
60	565.1	6.53																			55.9	.58
62	603.4	6.75																			58.0	.58
64	643.0	6.96																			60.1	.58

RECTANG. BEAMS LIMITED BY CONCRETE	
M_1/M	%A_s
1.01	103
1.02	106
1.03	110
1.04	114
1.05	117
1.06	121
1.07	125
1.08	129
1.09	133
1.10	137
1.11	141
1.12	145
1.13	150
1.14	154
1.15	159
1.16	164
1.17	169
1.18	175
1.19	181
1.20	187
1.21	193
1.22	198
1.23	204
1.24	211
1.25	218
1.26	225
1.27	232
1.28	239
1.29	248
1.30	256

M = Bending Moment, Kip ft. lbs. for balanced reinforcing.
M_1 = Moment in excess of M for beam size limited by conc.
M_c = Resist. Mom. Kip ft. lbs. of 1□″ compression steel
A_T = Sq. in. addn'l tensile steel for each 1□″ comp. steel.

UNIVERSAL BEAM TABLES

Rectangular Beams and Slabs with Balanced Reinforcing.
Rectangular Beams, Size Limited by Concrete Stress.
Tee Beams for Varying Slab Thickness.
Beams Reinforced for Compression.

$f_c = 875$
$f_s = 20000$
$n = 12$

$f'_c = 2500$
$f_c = 0.35 f'_c$

MOMENTS IN KIP FOOT POUNDS AND STEEL AREAS PER FOOT WIDTH

EFF. DEPTH	Rectang. Beams		TEE BEAMS FOR SLAB THICKNESSES SHOWN																		COMPRESSION REINF.		RECTANG. BEAMS LIMITED BY CONCRETE	
			2″		2½″		3″		3½″		4″		4½″		5″		5½″		6″					
"d"	M	As	M	As	M	As	M	As	M	As	M	As	M	As	M	As	M	As	M	As	Mc	AT	M_1/M	%As
1	.13	.09																						
½	.30	.14																					1.01	103
2	.53	.18																						
½	.83	.23																					1.02	105
3	1.2	.27																						
½	1.6	.32																					1.03	108
4	2.1	.36																						
½	2.7	.41																					1.04	111
5	3.3	.45																						
½	4.0	.50																					1.05	114
6	4.8	.54	4.8	.54																	.10	.02		
½	5.6	.59	5.6	.58																	.39	.05	1.06	119
7	6.5	.63	6.4	.61																	.68	.08		
½	7.5	.68	7.2	.64																	1.0	.11	1.07	122
8	8.5	.72	8.0	.67	8.5	.71															1.3	.13		
½	9.6	.77	8.9	.70	9.5	.75															1.7	.15	1.08	125
9	10.8	.81	9.7	.72	10.5	.79	10.8	.81													2.0	.17		
½	12.0	.86	10.5	.74	11.5	.82	12.0	.85													2.4	.19	1.09	129
10	13.3	.90	11.4	.75	12.5	.84	13.2	.89													2.7	.20		
½	14.7	.95	12.1	.76	13.6	.86	14.4	.93													3.1	.22	1.10	132
11	16.1	.99	12.9	.77	14.6	.88	15.6	.96	16.1	.99											3.4	.23		
½	17.6	1.04	13.8	.79	15.6	.90	16.8	.99	17.4	1.03											3.8	.24	1.11	136
12	19.2	1.08	14.7	.80	16.7	.92	18.0	1.01	18.8	1.07	19.2	1.09									4.1	.25		
½	20.8	1.13	15.6	.81	17.7	.94	19.3	1.03	20.3	1.10	20.8	1.13									4.5	.26	1.12	140
13	22.5	1.17	16.5	.82	18.8	.95	20.5	1.05	21.7	1.13	22.3	1.16									4.9	.27		
½	24.3	1.22	17.3	.83	19.9	.97	21.8	1.07	23.1	1.16	23.9	1.20									5.3	.28	1.13	144
14	26.1	1.27	18.2	.84	20.9	.98	23.0	1.09	24.5	1.18	25.5	1.23	26.1	1.26							5.6	.28		
½	28.1	1.32	19.0	.85	22.0	.99	24.3	1.10	26.0	1.20	27.2	1.26	27.9	1.30							6.0	.29	1.14	148
15	30.0	1.36	19.9	.85	23.0	1.00	25.5	1.11	27.4	1.21	28.8	1.29	29.6	1.34	30.0	1.35					6.4	.29		
½	32.1	1.41	20.8	.86	24.1	1.01	26.8	1.13	28.9	1.23	30.4	1.32	31.4	1.37	31.9	1.40					6.8	.30	1.15	152
16	34.1	1.45	21.6	.87	25.2	1.02	28.1	1.15	30.4	1.25	32.1	1.34	33.3	1.40	33.9	1.44	34.1	1.45			7.2	.31		
½	36.3	1.50	22.4	.88	26.3	1.03	29.3	1.16	31.8	1.27	33.7	1.36	35.1	1.43	35.9	1.47	36.2	1.49			7.6	.32	1.16	156
17	38.5	1.54	23.2	.88	27.3	1.04	30.6	1.18	33.3	1.29	35.4	1.39	37.9	1.45	38.4	1.50	38.4	1.53			7.9	.32		
18	43.2	1.63	25.1	.89	29.4	1.05	33.2	1.20	36.2	1.32	38.7	1.43	40.6	1.50	41.9	1.56	42.8	1.60	43.1	1.62	8.7	.33	1.17	160
19	48.1	1.72	26.8	.89	31.6	1.06	35.7	1.22	39.2	1.35	42.1	1.46	44.3	1.55	46.0	1.62	47.2	1.67	47.9	1.70	9.5	.33		
20	53.3	1.81	28.5	.90	33.7	1.07	38.3	1.24	42.2	1.38	45.4	1.49	48.0	1.59	50.1	1.67	51.6	1.73	52.6	1.77	10.2	.34	1.18	165
21	58.8	1.90	30.2	.91	35.9	1.08	40.9	1.25	45.2	1.39	48.7	1.51	51.8	1.62	54.2	1.71	56.1	1.78	57.5	1.84	11.0	.35		
22	64.5	1.99	32.0	.92	38.1	1.09	43.4	1.27	48.2	1.41	52.2	1.54	55.6	1.66	58.4	1.76	60.6	1.83	62.4	1.90	11.8	.35	1.19	170
23	70.5	2.08	33.7	.92	40.2	1.10	46.0	1.28	51.2	1.43	55.6	1.57	59.4	1.69	62.5	1.80	65.2	1.88	67.3	1.96	12.6	.36		
24	76.8	2.17	35.4	.93	42.4	1.11	48.6	1.29	54.1	1.45	59.0	1.59	63.3	1.72	66.8	1.84	69.8	1.92	72.2	2.01	13.4	.36	1.20	175
26	90.1	2.35			46.7	1.12	53.8	1.31	60.1	1.47	65.8	1.62	70.9	1.77	75.1	1.89	78.9	2.00	82.1	2.10	15.0	.37		
28	104.5	2.53			51.1	1.14	59.0	1.33	66.1	1.50	72.6	1.65	78.4	1.81	83.6	1.94	88.2	2.06	92.0	2.17	16.5	.38	1.21	180
30	120.0	2.71			55.5	1.15	64.2	1.35	72.0	1.53	79.5	1.68	86.3	1.85	92.1	1.98	97.4	2.11	102.1	2.23	18.1	.39		
32	136.5	2.89					69.4	1.36	78.3	1.55	86.4	1.71	94.0	1.89	100.6	2.02	106.7	2.16	112.3	2.29	19.7	.39	1.22	185
34	154.1	3.07					74.6	1.37	84.3	1.56	93.5	1.74	101.6	1.91	109.1	2.06	116.1	2.21	122.4	2.34	21.3	.40		
36	172.8	3.25					79.8	1.39	90.4	1.57	100.2	1.76	109.2	1.94	117.8	2.09	125.0	2.25	132.6	2.39	22.9	.40	1.23	191
38	192.5	3.43									107.1	1.78	117.0	1.96	126.5	2.12	134.5	2.28	142.9	2.43	24.4	.41		
40	213.3	3.61									114.0	1.80	124.9	1.98	135.0	2.15	143.7	2.31	153.0	2.46	26.1	.41	1.24	196
42	235.2	3.80									120.9	1.81	132.5	2.00	143.8	2.17	153.1	2.34	163.5	2.50	27.6	.41		
44	258.1	3.98													152.2	2.20	163.2	2.37	174.0	2.53	29.2	.42	1.25	201
46	282.1	4.16													160.6	2.22	172.9	2.39	184.2	2.56	30.8	.42		
48	307.2	4.34													169.9	2.24	182.4	2.41	194.0	2.58	32.4	.42	1.26	206
50	333.3	4.52																	204.8	2.60	34.0	.43		
52	360.5	4.70																	215.0	2.62	35.6	.43	1.27	211
54	388.8	4.88																	225.2	2.64	37.2	.43		
56	418.1	5.06																			38.8	.43	1.28	217
58	448.5	5.24																			40.4	.43		
60	480.0	5.42																			42.0	.43	1.29	223
62	512.5	5.60																			43.6	.43		
64	546.1	5.78																			45.2	.44	1.30	230

M = Bending Moment, Kip ft. lbs. for balanced reinforcing.
M_1 = Moment in excess of M for beam size limited by conc.
M_c = Resist. Mom. Kip ft. lbs. of 1□″ compression steel
A_T = Sq. in. addn'l tensile steel for each 1□″ comp. steel.

UNIVERSAL BEAM TABLES

Rectangular Beams and Slabs with Balanced Reinforcing.
Rectangular Beams, Size-Limited by Concrete Stress.
Tee Beams for Varying Slab Thickness.
Beams Reinforced for Compression.

$f_c = 1000$
$f_s = 20000$
$n = 12$

$f_c' = 2500$
$f_c = 0.40 f_c'$

MOMENTS IN KIP FOOT POUNDS AND STEEL AREAS PER FOOT WIDTH

EFF. DEPTH	Rectang. Beams		TEE BEAMS FOR SLAB THICKNESSES SHOWN																		COMPRESSION REINF.		RECTANG. BEAMS LIMITED BY CONCRETE	
			2″		2½″		3″		3½″		4″		4½″		5″		5½″		6″					
"d"	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M_c	A_T	M_1/M	%A_s
1	.16	.11																					1.01	103
½	.37	.17																						
2	.66	.23																					1.02	106
½	1.1	.28																						
3	1.5	.34																					1.03	109
½	2.0	.39																						
4	2.6	.45																					1.04	112
½	3.3	.51																						
5	4.1	.56																					1.05	116
½	5.0	.62																						
6	5.9	.68	5.9	.66																	.4	.06	1.06	120
½	6.9	.73	6.8	.71																	.8	.10		
7	8.0	.79	7.8	.76	8.0	.79															1.1	.13	1.07	124
½	9.2	.84	8.7	.79	9.2	.84															1.5	.16		
8	10.5	.90	9.6	.81	10.3	.88	10.5	.90													1.8	.18	1.08	127
½	11.9	.96	10.5	.83	11.4	.91	11.8	.95													2.2	.20		
9	13.3	1.01	11.4	.85	12.6	.95	13.1	1.00													2.6	.22	1.09	131
½	14.8	1.07	12.4	.87	13.8	.98	14.5	1.04													3.0	.24		
10	16.4	1.13	13.4	.89	14.9	1.00	15.9	1.08	16.3	1.12											3.4	.26	1.10	135
½	18.1	1.18	14.4	.90	16.1	1.02	17.3	1.11	17.9	1.17											3.9	.27		
11	19.9	1.24	15.3	.91	17.3	1.05	18.7	1.15	19.5	1.21	19.8	1.23									4.3	.28	1.11	139
½	21.7	1.29	16.3	.93	18.5	1.07	20.1	1.18	21.1	1.25	21.6	1.29									4.7	.30		
12	23.6	1.35	17.3	.94	19.7	1.09	21.5	1.20	22.7	1.29	23.4	1.34	23.6	1.35							5.1	.31	1.12	143
½	25.6	1.41	18.3	.95	20.9	1.10	22.9	1.22	24.4	1.32	25.2	1.38	25.6	1.40							5.5	.32		
13	27.7	1.46	19.2	.96	22.1	1.11	24.3	1.25	25.9	1.35	27.0	1.41	27.6	1.45							5.9	.32	1.13	147
½	30.0	1.52	20.2	.97	23.3	1.13	25.8	1.27	27.6	1.38	29.8	1.45	29.6	1.50							6.9	.33		
14	32.2	1.58	21.2	.98	24.5	1.14	27.2	1.29	29.3	1.41	30.8	1.49	31.6	1.55	32.2	1.58					6.8	.34	1.14	151
½	34.6	1.64	22.2	.99	25.7	1.15	28.7	1.31	31.0	1.43	32.6	1.53	33.7	1.59	34.3	1.63					7.8	.35		
15	36.9	1.69	23.2	.99	27.0	1.16	30.1	1.32	32.6	1.45	34.4	1.55	35.7	1.63	36.6	1.67	36.9	1.69			7.7	.35	1.15	156
½	39.5	1.75	24.2	1.00	28.2	1.18	31.6	1.34	34.3	1.47	36.3	1.58	37.8	1.67	38.8	1.71	39.4	1.74			8.2	.36		
16	42.0	1.80	25.2	1.00	29.4	1.19	33.0	1.36	35.9	1.49	38.2	1.60	39.9	1.70	41.1	1.75	41.8	1.79	42.0	1.80	8.6	.37	1.16	160
½	44.7	1.86	26.2	1.01	30.6	1.20	34.4	1.37	37.6	1.51	40.1	1.62	42.0	1.73	43.4	1.79	44.3	1.84	44.7	1.85	9.0	.38		
17	47.4	1.91	27.1	1.01	31.9	1.21	35.9	1.38	39.4	1.53	42.0	1.65	44.2	1.75	45.7	1.83	46.8	1.88	47.3	1.90	9.4	.38	1.17	165
18	53.2	2.03	29.1	1.02	34.3	1.23	38.8	1.40	42.7	1.56	45.9	1.69	48.4	1.80	50.4	1.89	51.7	1.95	52.7	2.00	10.3	.39		
19	59.2	2.14	31.1	1.03	36.8	1.24	41.8	1.42	46.1	1.59	49.8	1.73	52.6	1.85	55.0	1.95	55.6	2.02	58.1	2.09	11.2	.40	1.18	170
20	65.6	2.25	33.0	1.04	39.3	1.25	44.7	1.44	49.5	1.61	53.6	1.76	56.9	1.89	59.8	2.00	61.9	2.09	63.6	2.16	12.1	.40		
21	72.4	2.36	35.0	1.05	41.6	1.26	47.6	1.46	52.9	1.63	57.3	1.79	61.2	1.93	64.4	2.05	67.1	2.15	69.2	2.23	13.0	.41	1.19	175
22	79.4	2.48	37.0	1.05	44.2	1.27	50.5	1.48	56.3	1.65	61.3	1.82	65.6	1.97	69.2	2.09	72.3	2.20	74.7	2.29	13.9	.42		
23	86.8	2.59	39.0	1.06	46.6	1.28	53.5	1.49	59.7	1.67	65.1	1.85	70.0	2.00	74.1	2.13	77.4	2.25	80.4	2.35	14.8	.42	1.20	181
24	94.5	2.70	41.0	1.07	49.1	1.29	56.5	1.50	63.1	1.69	69.1	1.87	74.3	2.03	78.8	2.17	82.8	2.29	86.1	2.40	15.7	.43		
26	110.9	2.93			54.2	1.31	62.4	1.52	70.1	1.72	76.8	1.91	83.1	2.08	88.4	2.23	93.2	2.37	97.4	2.49	17.5	.44	1.21	186
28	128.6	3.15			59.2	1.33	68.4	1.54	77.0	1.75	84.7	1.94	91.8	2.12	98.2	2.29	103.9	2.44	108.8	2.58	19.3	.45		
30	147.7	3.38			64.2	1.34	74.3	1.56	83.9	1.78	92.5	1.97	100.5	2.16	108.0	2.34	114.5	2.50	119.2	2.64	21.1	.45	1.22	192
32	168.0	3.60					80.3	1.58	90.9	1.80	100.5	2.00	109.4	2.19	117.6	2.38	125.1	2.55	132.1	2.70	22.9	.46		
34	189.7	3.83					86.2	1.59	97.6	1.82	108.4	2.03	118.3	2.23	127.4	2.41	136.0	2.59	143.6	2.75	24.7	.46	1.23	198
36	212.6	4.05					92.2	1.60	104.5	1.83	116.4	2.05	127.2	2.26	137.3	2.44	146.7	2.63	155.5	2.80	26.6	.47		
38	236.9	4.28									124.2	2.07	136.0	2.28	147.2	2.47	157.4	2.67	167.2	2.84	28.4	.47	1.24	204
40	262.5	4.50									132.1	2.09	145.1	2.30	157.1	2.50	168.3	2.70	178.8	2.88	30.2	.48		
42	289.4	4.73									139.7	2.10	153.6	2.31	166.6	2.53	179.0	2.73	190.9	2.92	32.0	.48	1.25	210
44	317.6	4.95													176.6	2.55	190.0	2.75	202.2	2.95	33.8	.48		
46	347.2	5.18													186.6	2.57	200.9	2.77	214.1	2.98	35.7	.49	1.26	216
48	378.0	5.40													196.5	2.59	211.5	2.79	226.0	3.00	37.5	.49		
50	410.2	5.63																	237.8	3.03	39.3	.49	1.27	222
52	443.6	5.85																	250.0	3.06	41.1	.49		
54	478.4	6.08																	262.0	3.08	43.0	.50	1.28	229
56	514.5	6.30																			44.8	.50		
58	551.9	6.53																			46.6	.50	1.29	236
60	590.6	6.75																			48.4	.50		
62	630.7	6.98																			50.2	.50	1.30	244
64	672.0	7.20																			52.0	.50		

M = Bending Moment, Kip ft. lbs. for balanced reinforcing.
M₁ = Moment in excess of M for beam size limited by conc.
Mc = Resist. Mom. Kip ft. lbs. of 1 □″ compression steel
Aт = Sq. in. addn'l tensile steel for each 1 □″ comp. steel.

UNIVERSAL BEAM TABLES

Rectangular Beams and Slabs with Balanced Reinforcing.
Rectangular Beams, Size Limited by Concrete Stress.
Tee Beams for Varying Slab Thickness.
Beams Reinforced for Compression.

$f_c = 1125$
$f_s = 20000$
$n = 12$

$f'_c = 2500$
$f_c = 0.45 f'_c$

MOMENTS IN KIP FOOT POUNDS AND STEEL AREAS PER FOOT WIDTH

EFF. DEPTH	Rectang. Beams		TEE BEAMS FOR SLAB THICKNESSES SHOWN 2″		2½″		3″		3½″		4″		4½″		5″		5½″		6″		COMPRESSION REINF.	
"d"	M	As	M	As	M	As	M	As	M	As	M	As	M	As	M	As	M	As	M	As	Mc	Aт
1	.20	.14																				
½	.44	.20																				
2	.79	.27																				
½	1.2	.34																				
3	1.8	.41																				
½	2.4	.48																				
4	3.1	.54																				
½	4.0	.61																				
5	4.9	.68																				
½	5.9	.75																				
6	7.1	.82	6.9	.79																	.7	.11
½	8.3	.88	7.9	.84																	1.1	.15
7	9.6	.95	9.0	.87	9.5	.94															1.5	.18
½	11.0	1.02	10.1	.90	10.8	.99															2.0	.21
8	12.6	1.09	11.1	.93	12.1	1.04	12.3	1.09													2.4	.24
½	14.2	1.16	12.2	.95	12.8	1.08	13.9	1.14													2.8	.26
9	15.9	1.22	13.2	.98	14.7	1.10	15.5	1.19													3.2	.28
½	17.7	1.29	14.3	1.00	16.0	1.13	17.1	1.23													3.7	.30
10	19.6	1.36	15.4	1.02	17.3	1.16	18.7	1.27	19.4	1.34	19.6	1.36									4.2	.31
½	21.6	1.43	16.5	1.04	18.7	1.19	20.2	1.31	21.2	1.39	21.6	1.43									4.7	.33
11	23.7	1.50	17.6	1.05	20.0	1.21	21.8	1.34	22.9	1.43	23.6	1.49									5.1	.34
½	26.0	1.56	18.7	1.06	21.4	1.23	23.4	1.37	24.8	1.47	25.6	1.54									5.6	.35
12	28.3	1.63	19.8	1.07	22.7	1.25	25.0	1.40	26.6	1.51	27.6	1.59	28.2	1.62							6.0	.36
½	30.7	1.70	20.9	1.08	24.1	1.27	26.6	1.43	28.5	1.55	29.7	1.64	30.4	1.69							6.5	.37
13	33.2	1.77	22.0	1.09	25.4	1.29	28.2	1.45	30.3	1.58	31.8	1.68	32.7	1.74	33.1	1.76					7.0	.38
½	35.9	1.84	23.1	1.10	26.8	1.31	29.8	1.47	32.2	1.61	33.8	1.71	28.8	1.79	35.6	1.82					7.5	.39
14	38.5	1.90	24.2	1.11	28.2	1.32	31.4	1.49	34.0	1.63	35.9	1.74	37.3	1.84	38.1	1.87	38.4	1.90			8.0	.40
½	41.4	1.97	25.3	1.12	29.5	1.33	33.1	1.51	35.9	1.65	38.0	1.77	39.6	1.88	40.7	1.92	41.2	1.96			8.5	.41
15	44.2	2.04	26.4	1.13	30.9	1.34	34.7	1.53	37.7	1.67	40.1	1.80	42.0	1.91	43.2	1.97	43.9	2.02	44.2	2.04	9.0	.41
½	47.2	2.11	27.5	1.13	32.3	1.35	36.3	1.55	39.6	1.70	42.3	1.83	44.3	1.95	45.8	2.02	46.7	2.07	47.1	2.10	9.5	.42
16	50.2	2.18	28.6	1.14	33.7	1.36	37.9	1.56	41.5	1.73	44.4	1.86	46.7	1.98	48.3	2.07	49.4	2.12	50.0	2.16	10.0	.43
½	53.5	2.25	29.7	1.14	35.1	1.37	39.6	1.57	43.4	1.75	46.5	1.89	49.0	2.01	50.9	2.11	52.2	2.17	53.1	2.22	10.5	.44
17	56.7	2.31	30.9	1.15	36.5	1.38	41.3	1.59	45.3	1.76	48.7	1.91	51.4	2.04	53.5	2.15	55.0	2.22	56.1	2.27	11.0	.44
18	63.6	2.45	33.1	1.17	39.2	1.40	44.5	1.61	49.2	1.79	53.0	1.95	56.2	2.09	58.7	2.21	60.8	2.30	62.2	2.36	12.0	.45
19	70.8	2.58	35.3	1.18	42.0	1.42	47.8	1.63	52.9	1.81	57.3	1.99	61.0	2.14	64.1	2.27	66.5	2.38	68.3	2.45	13.0	.46
20	78.5	2.72	37.5	1.19	44.8	1.43	51.1	1.65	56.8	1.85	61.7	2.02	65.9	2.19	69.4	2.32	72.2	2.45	74.6	2.54	14.0	.47
21	86.5	2.86	39.8	1.19	47.5	1.44	54.5	1.66	60.6	1.87	66.1	2.06	70.7	2.23	74.7	2.37	78.1	2.51	80.8	2.61	15.0	.47
22	95.0	2.99	42.0	1.20	50.4	1.46	57.8	1.68	64.5	1.90	70.4	2.09	75.6	2.26	80.0	2.42	83.9	2.56	87.1	2.67	16.0	.48
23	103.8	3.13	44.2	1.21	53.0	1.47	61.0	1.70	68.4	1.92	74.8	2.12	80.5	2.29	85.4	2.46	89.8	2.61	93.5	2.73	17.0	.49
24	113.0	3.26	46.5	1.21	55.9	1.48	64.4	1.71	72.1	1.94	79.2	2.14	85.3	2.32	90.9	2.50	95.7	2.66	99.9	2.79	18.0	.49
26	132.7	3.54			61.6	1.49	71.0	1.73	80.0	1.97	87.9	2.18	95.3	2.37	101.8	2.57	107.6	2.73	112.7	2.88	20.0	.50
28	153.8	3.81			67.1	1.50	77.8	1.75	87.6	2.00	96.8	2.21	105.1	2.42	112.8	2.62	119.5	2.80	125.7	2.97	22.1	.51
30	176.6	4.08			72.8	1.51	84.3	1.77	95.5	2.02	105.7	2.24	115.0	2.46	123.7	2.67	131.5	2.86	138.8	3.04	24.1	.52
32	200.9	4.35					91.1	1.79	103.2	2.04	114.5	2.27	124.9	2.50	134.7	2.72	143.7	2.92	151.7	3.10	26.1	.52
34	226.8	4.62					97.8	1.80	111.0	2.06	123.4	2.30	135.0	2.54	145.7	2.76	155.7	2.96	164.9	3.15	28.2	.53
36	254.3	4.90					104.5	1.81	119.0	2.07	132.3	2.32	144.9	2.57	156.7	2.79	167.8	3.00	178.1	3.20	30.2	.53
38	283.4	5.17									141.3	2.34	155.1	2.59	167.7	2.81	179.8	3.04	191.2	3.25	32.3	.54
40	314.0	5.44									150.1	2.36	153.9	2.61	178.9	2.85	192.1	3.07	204.4	3.30	34.3	.54
42	346.2	5.71									159.1	2.38	175.0	2.63	189.8	2.87	204.1	3.10	217.8	3.34	36.4	.55
44	379.9	5.98													201.1	2.90	216.4	3.13	231.2	3.37	38.4	.55
46	415.2	6.26													212.2	2.92	228.6	3.16	244.4	3.40	40.5	.55
48	452.1	6.53													223.4	2.94	240.8	3.18	257.6	3.42	42.5	.55
50	490.6	6.80																	271.3	3.45	44.6	.56
52	530.6	7.07																	284.4	3.47	46.6	.56
54	572.2	7.34																	297.7	3.49	48.7	.56
56	615.4	7.62																			50.8	.56
58	660.1	7.89																			52.8	.57
60	706.4	8.16																			54.9	.57
62	754.3	8.43																			57.0	.57
64	803.8	8.70																			59.0	.57

RECTANG. BEAMS LIMITED BY CONCRETE	
M_1/M	%As
1.01	103
1.02	106
1.03	110
1.04	114
1.05	117
1.06	121
1.07	125
1.08	129
1.09	133
1.10	137
1.11	141
1.12	145
1.13	150
1.14	154
1.15	159
1.16	164
1.17	169
1.18	175
1.19	181
1.20	187
1.21	193
1.22	198
1.23	204
1.24	211
1.25	218
1.26	225
1.27	232
1.28	239
1.29	248
1.30	256

M = Bending Moment, Kip ft. lbs. for balanced reinforcing.
M_1 = Moment in excess of M for beam size limited by conc.
M_c = Resist. Mom. Kip ft. lbs. of 1□″ compression steel
A_T = Sq. in. addn'l tensile steel for each 1□″ comp. steel.

UNIVERSAL BEAM TABLES

Rectangular Beams and Slabs with Balanced Reinforcing.
Rectangular Beams, Size Limited by Concrete Stress.
Tee Beams for Varying Slab Thickness.
Beams Reinforced for Compression.

$f_c = 1050$
$f_s = 20000$
$n = 10$

$f'_c = 3000$
$f_c = 0.35 f'_c$

MOMENTS IN KIP FOOT POUNDS AND STEEL AREAS PER FOOT WIDTH

EFF. DEPTH	Rectang. Beams		TEE BEAMS FOR SLAB THICKNESSES SHOWN 2″		2½″		3″		3½″		4″		4½″		5″		5½″		6″		COMPRESSION REINF.	
"d"	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M_c	A_T
1	.16	.11																				
½	.36	.16																				
2	.64	.22																				
½	1.0	.27																				
3	1.4	.33																				
½	2.0	.38																				
4	2.6	.43																				
½	3.2	.49																				
5	4.0	.54																				
½	4.8	.60																				
6	5.8	.65	5.8	.65																	.10	.02
½	6.8	.70	6.7	.69																	.39	.05
7	7.8	.76	7.7	.74																	.67	.08
½	9.0	.81	8.6	.78																	.98	.11
8	10.2	.87	9.6	.81	10.2	.85															1.3	.13
½	11.6	.92	10.6	.84	11.4	.90															1.6	.15
9	13.0	.98	11.6	.86	12.6	.95	12.9	.97													2.0	.17
½	14.4	1.03	12.6	.88	13.8	.98	14.4	1.02													2.3	.19
10	16.0	1.08	13.6	.90	15.0	1.01	15.8	1.07													2.6	.20
½	17.6	1.14	14.5	.92	16.3	1.04	17.3	1.11													3.0	.21
11	19.4	1.19	15.5	.93	17.5	1.06	18.7	1.14	19.3	1.18											3.3	.22
½	21.2	1.25	16.6	.95	18.8	1.09	20.2	1.17	20.9	1.23											3.7	.23
12	23.0	1.30	17.7	.97	20.0	1.11	21.6	1.20	22.6	1.28	23.0	1.30									4.1	.24
½	25.0	1.36	18.7	.98	21.3	1.13	23.1	1.23	24.3	1.32	24.9	1.35									4.5	.25
13	27.0	1.41	19.8	.99	22.5	1.14	24.6	1.26	26.0	1.35	26.8	1.39									4.8	.26
½	29.2	1.47	20.8	1.00	23.8	1.16	26.1	1.28	27.7	1.38	28.7	1.44									5.2	.27
14	31.4	1.52	21.8	1.01	25.1	1.17	27.6	1.30	29.4	1.41	30.6	1.48	31.3	1.51							5.5	.28
½	33.7	1.58	22.8	1.02	26.4	1.18	29.1	1.32	31.2	1.44	32.6	1.51	33.4	1.56							5.9	.29
15	36.0	1.63	23.8	1.02	27.6	1.20	30.6	1.34	32.9	1.46	34.6	1.54	35.6	1.60	36.0	1.62					6.3	.29
½	38.5	1.69	24.9	1.03	28.9	1.21	32.1	1.36	34.7	1.49	36.5	1.57	37.7	1.64	38.3	1.68					6.7	.30
16	41.0	1.74	25.9	1.04	30.3	1.22	33.6	1.38	36.5	1.51	38.5	1.60	39.9	1.68	40.7	1.73	41.0	1.74			7.0	.30
½	43.6	1.79	26.9	1.05	31.5	1.23	35.2	1.39	38.2	1.53	40.4	1.63	42.1	1.71	43.1	1.77	43.5	1.79			7.4	.31
17	46.2	1.84	27.8	1.06	32.8	1.24	36.7	1.41	39.9	1.55	42.4	1.66	44.3	1.74	45.5	1.80	46.1	1.83			7.8	.31
18	51.8	1.95	30.0	1.07	35.3	1.26	39.8	1.44	43.4	1.59	46.4	1.70	48.7	1.80	50.4	1.88	51.3	1.92	51.8	1.95	8.5	.32
19	57.8	2.06	32.1	1.07	37.9	1.28	42.8	1.46	47.1	1.62	50.5	1.74	53.2	1.85	55.2	1.95	56.6	2.01	57.5	2.04	9.3	.33
20	64.0	2.17	34.2	1.08	40.5	1.29	45.9	1.48	50.6	1.65	54.5	1.78	57.6	1.90	60.3	2.01	61.9	2.08	63.2	2.13	10.1	.34
21	70.6	2.28	36.3	1.08	43.1	1.30	49.0	1.50	54.2	1.67	58.4	1.81	62.2	1.95	65.1	2.06	67.4	2.14	69.0	2.20	10.8	.34
22	77.4	2.39	38.4	1.09	45.7	1.31	52.1	1.52	57.8	1.70	62.6	1.84	66.8	1.99	70.1	2.11	72.8	2.20	74.9	2.27	11.6	.35
23	84.6	2.49	40.5	1.10	48.3	1.32	55.2	1.53	61.4	1.72	66.7	1.87	71.3	2.03	75.0	2.16	78.2	2.26	80.7	2.34	12.4	.35
24	92.2	2.60	42.5	1.11	50.9	1.33	58.4	1.54	65.0	1.74	70.8	1.90	75.9	2.07	80.2	2.20	83.7	2.31	86.6	2.41	13.1	.36
26	108.2	2.82			56.1	1.35	64.5	1.57	72.2	1.77	78.9	1.95	85.1	2.13	90.2	2.26	94.6	2.40	98.6	2.52	14.7	.37
28	125.4	3.04			61.4	1.37	70.8	1.59	79.4	1.80	87.2	1.99	94.1	2.18	100.4	2.32	105.7	2.47	110.4	2.61	16.2	.37
30	144.0	3.25			66.6	1.38	77.0	1.61	86.3	1.83	95.4	2.02	103.5	2.22	110.5	2.38	116.8	2.54	122.5	2.68	17.8	.38
32	163.8	3.47					83.3	1.63	94.0	1.86	103.6	2.05	112.7	2.26	120.7	2.43	128.1	2.60	134.7	2.74	19.3	.39
34	185.0	3.69					89.6	1.65	101.1	1.88	112.2	2.10	122.0	2.30	131.0	2.47	139.4	2.66	146.9	2.80	20.9	.39
36	207.4	3.90					95.7	1.66	108.5	1.89	120.3	2.12	131.0	2.33	141.4	2.51	150.0	2.70	159.1	2.85	22.5	.40
38	231.0	4.12									128.5	2.14	140.4	2.35	151.8	2.55	161.5	2.74	171.5	2.90	24.0	.40
40	256.0	4.34									136.8	2.16	149.8	2.37	162.0	2.58	172.5	2.77	183.5	2.95	25.6	.40
42	282.2	4.55									145.0	2.17	159.0	2.40	172.5	2.61	183.8	2.80	196.2	3.00	27.1	.41
44	309.8	4.77													182.6	2.64	196.0	2.84	208.8	3.03	28.7	.41
46	338.6	499													192.7	2.66	207.5	2.87	221.0	3.06	30.3	.41
48	368.6	5.21													203.8	2.68	218.9	2.90	232.8	3.09	31.8	.42
50	400.0	5.42																	245.7	3.12	33.4	.42
52	432.6	5.64																	258.0	3.14	35.0	.42
54	466.6	5.86																	270.3	3.16	36.5	.42
56	501.8	6.07																			38.1	.42
58	538.2	6.29																			39.7	.43
60	576.0	6.51																			41.3	.43
62	615.0	6.72																			42.9	.43
64	655.3	6.94																			44.5	.43

RECTANG. BEAMS LIMITED BY CONCRETE	
M_1/M	%A_s
1.01	103
1.02	105
1.03	108
1.04	111
1.05	114
1.06	119
1.07	122
1.08	125
1.09	129
1.10	132
1.11	136
1.12	140
1.13	144
1.14	148
1.15	152
1.16	156
1.17	160
1.18	165
1.19	170
1.20	175
1.21	180
1.22	185
1.23	191
1.24	196
1.25	201
1.26	206
1.27	211
1.28	217
1.29	223
1.30	230

M = Bending Moment, Kip ft. lbs. for balanced reinforcing.
M_1 = Moment in excess of M for beam size limited by conc.
M_c = Resist. Mom. Kip ft. lbs. of 1 □" compression steel
A_T = Sq. in. addn'l tensile steel for each 1 □" comp. steel.

UNIVERSAL BEAM TABLES

Rectangular Beams and Slabs with Balanced Reinforcing.
Rectangular Beams, Size Limited by Concrete Stress.
Tee Beams for Varying Slab Thickness.
Beams Reinforced for Compression.

$f_c = 1200$
$f_s = 20000$
$n = 10$

$f'_c = 3000$
$f_c = 0.40 f'_c$

MOMENTS IN KIP FOOT POUNDS AND STEEL AREAS PER FOOT WIDTH

EFF. DEPTH	Rectang. Beams		TEE BEAMS FOR SLAB THICKNESSES SHOWN																		COMPRESSION REINF.		RECTANG. BEAMS LIMITED BY CONCRETE	
			2"		2½"		3"		3½"		4"		4½"		5"		5½"		6"					
"d"	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M_c	A_T	M_1/M	%A_s
1	.20	.14																						
½	.44	.20																					1.01	103
2	.79	.27																						
½	1.2	.34																					1.02	106
3	1.8	.41																						
½	2.4	.47																					1.03	109
4	3.2	.54																						
½	4.0	.61																					1.04	112
5	4.9	.68																						
½	6.0	.74																					1.05	116
6	7.1	.81	7.0	.80																	.40	.06		
½	8.3	.88	8.2	.86																	.73	.10	1.06	120
7	9.6	.95	9.4	.92	9.6	.95															1.1	.13		
½	11.1	1.01	10.5	.95	11.0	1.00															1.5	.16	1.07	124
8	12.6	1.08	11.5	.97	12.3	1.05	12.6	1.08													1.8	.18		
½	14.2	1.15	12.6	.99	13.7	1.10	14.2	1.14													2.2	.20	1.08	127
9	15.9	1.22	13.7	1.02	15.1	1.14	15.8	1.20													2.6	.22		
½	17.8	1.28	14.9	1.04	16.5	1.17	17.4	1.25													3.0	.24	1.09	131
10	19.7	1.35	16.1	1.06	17.9	1.20	19.1	1.29	19.6	1.35											3.4	.25		
½	21.7	1.42	17.2	1.08	19.3	1.23	20.8	1.33	21.5	1.41											3.8	.27	1.10	135
11	23.8	1.49	18.4	1.10	20.8	1.26	22.4	1.38	23.4	1.46	23.8	1.48									4.2	.28		
½	26.0	1.55	19.5	1.12	22.2	1.28	24.1	1.41	25.4	1.50	25.9	1.54									4.6	.29	1.11	139
12	28.4	1.62	20.7	1.13	23.6	1.30	25.8	1.44	27.3	1.55	28.1	1.60	28.4	1.62							5.0	.30		
½	30.8	1.69	21.9	1.14	25.1	1.32	27.5	1.47	29.2	1.59	30.3	1.65	30.8	1.68							5.4	.31	1.12	143
13	33.3	1.76	23.0	1.15	26.5	1.34	29.2	1.50	31.1	1.62	32.5	1.69	33.2	1.74							5.8	.32		
½	36.0	1.83	24.2	1.16	28.0	1.36	30.9	1.53	33.1	1.65	34.7	1.74	35.6	1.80							6.3	.33	1.13	147
14	38.6	1.89	25.4	1.17	29.4	1.37	32.6	1.56	35.1	1.68	36.9	1.79	38.1	1.85	38.5	1.89					6.7	.33		
½	41.5	1.96	26.6	1.18	30.9	1.38	34.4	1.58	37.1	1.71	39.1	1.83	40.5	1.90	41.2	1.95					7.1	.34	1.14	151
15	44.3	2.03	27.8	1.19	32.4	1.40	36.1	1.60	39.1	1.74	41.3	1.86	42.9	1.95	43.9	2.00	44.3	2.03			7.5	.35		
½	47.4	2.10	29.0	1.20	33.8	1.42	37.8	1.62	41.1	1.77	43.6	1.89	45.4	1.99	46.6	2.05	47.2	2.09			8.0	.36	1.15	156
16	50.4	2.16	30.1	1.21	35.3	1.43	39.6	1.63	43.1	1.79	45.9	1.92	47.9	2.03	49.3	2.10	50.2	2.15	50.4	2.16	8.4	.36		
½	53.7	2.23	31.3	1.22	36.8	1.44	41.3	1.64	45.2	1.81	48.2	1.95	50.5	2.07	52.1	2.15	53.2	2.20	53.5	2.22	8.9	.37	1.16	160
17	56.9	2.30	32.5	1.23	38.3	1.45	43.1	1.65	47.2	1.83	50.4	1.98	53.0	2.10	54.8	2.19	56.1	2.25	56.7	2.28	9.3	.37		
18	63.8	2.43	34.9	1.24	41.2	1.47	46.6	1.68	51.2	1.86	55.0	2.03	58.1	2.16	60.5	2.27	62.1	2.34	63.1	2.40	10.1	.38	1.17	165
19	71.1	2.57	37.3	1.25	44.1	1.49	50.1	1.71	55.3	1.90	59.6	2.08	63.2	2.21	66.0	2.34	68.2	2.42	69.7	2.50	11.0	.39		
20	78.8	2.70	39.8	1.25	47.1	1.50	53.6	1.73	59.4	1.94	64.2	2.12	68.4	2.26	71.7	2.40	74.3	2.50	76.4	2.60	11.9	.40	1.18	170
21	86.8	2.84	42.0	1.26	50.0	1.51	57.2	1.75	63.5	1.97	68.8	2.15	73.5	2.31	77.3	2.46	80.5	2.58	83.0	2.67	12.8	.40		
22	95.3	2.97	44.4	1.27	53.0	1.52	60.7	1.77	67.5	1.99	73.5	2.18	78.7	2.35	83.0	2.51	86.8	2.64	89.7	2.75	13.6	.41	1.19	175
23	104.1	3.11	46.7	1.27	56.0	1.53	64.2	1.79	71.6	2.01	78.2	2.21	84.0	2.39	88.9	2.56	92.9	2.70	96.5	2.82	14.5	.41		
24	113.4	3.24	49.3	1.28	59.0	1.54	67.8	1.80	75.8	2.03	83.0	2.24	89.2	2.43	94.6	2.60	99.4	2.75	103.2	2.88	15.4	.42	1.20	181
26	133.1	3.51			65.0	1.57	74.9	1.83	84.1	2.07	92.2	2.29	99.7	2.49	106.1	2.69	111.7	2.84	116.8	2.99	17.2	.43		
28	154.4	3.78			71.0	1.59	82.0	1.85	92.3	2.10	101.7	2.33	110.0	2.55	117.7	2.75	124.5	2.93	130.6	3.09	18.9	.44	1.21	186
30	177.2	4.05			77.0	1.61	89.2	1.87	100.5	2.13	110.8	2.37	120.6	2.59	129.5	2.80	137.3	3.00	144.5	3.17	20.7	.44		
32	201.6	4.32					96.4	1.89	108.9	2.16	120.5	2.40	131.2	2.63	141.2	2.85	150.1	3.06	158.5	3.24	22.5	.45	1.22	192
34	227.6	4.59					103.4	1.90	117.1	2.17	130.0	2.43	141.9	2.67	152.9	2.90	163.2	3.10	172.4	3.30	24.3	.46		
36	255.2	4.86					110.5	1.92	125.3	2.19	139.6	2.46	152.7	2.70	164.8	2.94	176.0	3.15	186.5	3.35	26.1	.46	1.23	198
38	284.3	5.13									148.9	2.48	163.2	2.73	176.7	2.97	188.9	3.20	200.8	3.40	27.9	.46		
40	315.0	5.40									158.7	2.50	174.1	2.76	188.5	3.00	201.8	3.24	214.6	3.45	29.6	.47	1.24	204
42	347.3	5.67									167.7	2.51	184.4	2.78	200.0	3.03	214.7	3.27	229.0	3.50	31.4	.47		
44	381.2	5.94													212.1	3.06	228.1	3.30	242.7	3.54	33.2	.47	1.25	210
46	416.6	6.21													224.0	3.08	241.0	3.32	256.9	3.57	35.0	.48		
48	453.6	6.48													236.0	3.10	253.8	3.34	271.2	3.60	36.8	.48	1.26	216
50	492.2	6.75																	285.0	3.63	38.6	.48	1.27	222
52	532.4	7.02																	300.0	3.66	40.4	.48		
54	574.1	7.29																	314.2	3.69	42.2	.49	1.28	229
56	617.4	7.56																			44.0	.49		
58	662.3	7.83																			45.8	.49	1.29	236
60	708.8	8.10																			47.6	.49		
62	756.8	8.37																			49.4	.49	1.30	244
64	806.4	8.64																			51.2	.49		

M = Bending Moment, Kip ft. lbs. for balanced reinforcing.
M_1 = Moment in excess of M for beam size limited by conc.
M_c = Resist. Mom. Kip ft. lbs. of 1 □″ compression steel
A_T = Sq. in. addn'l tensile steel for each 1 □″ comp. steel.

UNIVERSAL BEAM TABLES

Rectangular Beams and Slabs with Balanced Reinforcing.
Rectangular Beams, Size Limited by Concrete Stress.
Tee Beams for Varying Slab Thickness.
Beams Reinforced for Compression.

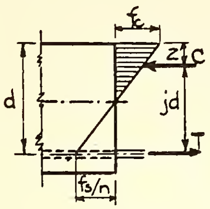
$f_c = 1350$
$f_s = 20000$
$n = 10$

$f'_c = 3000$
$f_c = 0.45 f'_c$

MOMENTS IN KIP FOOT POUNDS AND STEEL AREAS PER FOOT WIDTH

EFF. DEPTH	Rectang. Beams		TEE BEAMS FOR SLAB THICKNESSES SHOWN																		COMPRESSION REINF.	
			2″		2½″		3″		3½″		4″		4½″		5″		5½″		6″			
"d"	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M	A_s	M_c	A_T
1	.24	.16																				
½	.53	.24																				
2	.94	.33																				
½	1.5	.41																				
3	2.1	.49																				
½	2.9	.57																				
4	3.8	.65																				
½	4.8	.73																				
5	5.9	.82																				
½	7.1	.90																				
6	8.5	.98	8.3	.94																	.7	.11
½	9.9	1.06	9.5	1.01																	1.1	.15
7	11.5	1.14	10.8	1.05	11.4	1.12															1.5	.18
½	13.2	1.22	12.1	1.08	12.9	1.18															1.9	.21
8	15.1	1.31	13.3	1.11	14.5	1.24	14.8	1.30													2.3	.23
½	17.0	1.39	14.6	1.14	15.3	1.29	16.7	1.36													2.8	.25
9	19.1	1.47	15.9	1.17	17.6	1.33	18.6	1.42													3.2	.27
½	21.3	1.55	17.2	1.20	19.2	1.37	20.5	1.47													3.7	.29
10	23.5	1.63	18.5	1.22	20.8	1.40	22.4	1.52	23.2	1.60	23.6	1.63									4.1	.31
½	26.0	1.71	19.8	1.24	22.4	1.42	24.2	1.57	25.4	1.67	25.9	1.71									4.6	.32
11	28.5	1.80	21.1	1.26	24.0	1.45	26.1	1.61	27.5	1.71	28.3	1.78									5.0	.33
½	31.1	1.88	22.4	1.27	25.7	1.48	28.0	1.65	29.7	1.76	30.7	1.84									5.5	.35
12	33.9	1.96	23.7	1.28	27.2	1.50	30.0	1.68	32.0	1.81	33.2	1.90	33.8	1.95							5.9	.36
½	36.8	2.04	25.1	1.29	28.9	1.53	31.9	1.71	34.2	1.86	35.6	1.96	36.5	2.02							6.4	.37
13	39.8	2.12	26.4	1.30	30.5	1.55	33.8	1.74	36.4	1.89	38.1	2.01	39.2	2.09	39.8	2.12					6.9	.38
½	43.0	2.20	27.7	1.31	32.2	1.57	35.7	1.77	38.6	1.92	40.6	2.05	34.5	2.15	42.7	2.19					7.4	.39
14	46.2	2.28	29.0	1.32	33.8	1.58	37.7	1.80	40.8	1.95	43.1	2.09	44.8	2.20	45.7	2.25	46.1	2.28			7.8	.39
½	49.6	2.37	30.4	1.33	35.5	1.59	39.7	1.82	43.1	1.98	45.6	2.13	47.6	2.25	48.8	2.31	49.4	2.36			8.3	.40
15	53.0	2.45	31.7	1.34	37.1	1.61	41.6	1.84	45.3	2.01	48.2	2.17	50.4	2.29	51.8	2.37	52.7	2.43	53.0	2.45	8.8	.41
½	56.7	2.53	33.0	1.35	38.8	1.63	43.6	1.86	47.5	2.04	50.7	2.20	53.2	2.34	54.9	2.43	56.0	2.49	56.5	2.52	9.3	.42
16	60.3	2.61	34.4	1.36	40.4	1.64	45.5	1.88	49.8	2.07	53.3	2.23	56.0	2.38	58.0	2.49	59.3	2.55	60.0	2.59	9.8	.42
½	64.2	2.69	35.7	1.37	42.1	1.65	47.5	1.89	52.2	2.10	55.8	2.26	58.8	2.42	61.1	2.54	62.7	2.61	63.7	2.66	10.3	.43
17	68.1	2.77	37.1	1.38	43.7	1.66	49.5	1.90	54.4	2.12	58.4	2.30	61.7	2.45	64.2	2.58	66.0	2.66	67.3	2.73	10.8	.43
18	76.3	2.94	39.7	1.40	47.0	1.68	53.5	1.93	59.0	2.16	63.5	2.35	67.4	2.51	70.5	2.65	72.9	2.75	74.6	2.85	11.7	.44
19	85.0	3.10	42.4	1.42	50.3	1.70	57.4	1.96	63.5	2.19	68.8	2.39	73.2	2.57	76.9	2.72	79.8	2.84	82.0	2.96	12.7	.45
20	94.2	3.26	45.1	1.43	53.7	1.71	61.3	1.98	68.1	2.22	74.0	2.43	79.0	2.63	83.2	2.79	86.7	2.93	89.5	3.06	13.7	.46
21	103.8	3.43	47.7	1.44	57.0	1.73	65.4	2.00	72.7	2.25	79.3	2.47	84.8	2.67	89.7	2.85	93.7	3.02	97.0	3.14	14.7	.46
22	114.0	3.59	50.5	1.45	60.5	1.75	69.4	2.02	77.4	2.28	84.5	2.51	90.7	2.71	96.0	2.90	100.7	3.08	104.6	3.21	15.7	.47
23	124.6	3.75	53.0	1.46	63.7	1.76	73.3	2.04	82.1	2.31	89.7	2.54	96.6	2.75	102.5	2.95	107.8	3.14	112.2	3.28	16.7	.48
24	135.6	3.92	55.8	1.47	67.2	1.77	77.2	2.06	86.5	2.33	95.0	2.57	102.4	2.79	109.0	3.00	114.9	3.20	119.9	3.34	17.7	.48
26	159.2	4.24			73.9	1.78	85.3	2.08	96.0	2.36	105.5	2.62	114.4	2.86	122.1	3.08	129.1	3.28	135.3	3.46	19.7	.49
28	184.6	4.57			80.5	1.80	93.4	2.10	105.2	2.39	116.2	2.66	126.2	2.91	135.3	3.15	143.3	3.36	150.8	3.55	21.7	.50
30	211.9	4.90			87.4	1.82	101.3	2.12	114.6	2.42	126.9	2.70	138.0	2.96	148.4	3.21	157.8	3.43	166.5	3.64	23.7	.51
32	241.1	5.22					109.4	2.14	123.8	2.45	137.4	2.73	149.9	3.00	161.7	3.27	172.5	3.51	182.0	3.72	25.7	.51
34	272.2	5.55					117.4	2.16	133.2	2.47	148.1	2.76	162.0	3.04	174.9	3.32	186.9	3.56	197.8	3.80	27.7	.52
36	305.2	5.88					125.4	2.17	142.7	2.49	158.8	2.79	173.9	3.08	188.0	3.36	201.3	3.61	213.7	3.86	29.7	.52
38	340.0	6.20									169.6	2.82	186.1	3.11	201.2	3.39	215.8	3.65	229.4	3.91	31.7	.53
40	376.8	6.53									180.1	2.84	184.7	3.14	214.6	3.42	230.5	3.69	245.3	3.96	33.7	.53
42	415.4	6.85									190.9	2.87	210.0	3.17	227.8	3.45	244.9	3.72	261.4	4.00	35.7	.54
44	455.9	7.18													241.3	3.48	259.7	3.76	277.4	4.04	37.7	.54
46	498.3	7.51													254.7	3.51	274.4	3.79	293.3	4.08	39.7	.54
48	542.5	7.83													268.1	3.53	289.0	3.82	309.1	4.11	41.8	.55
50	588.7	8.16																	325.5	4.14	43.8	.55
52	636.7	8.49																	341.3	4.17	45.8	.55
54	686.6	8.81																	357.2	4.19	47.8	.55
56	738.5	9.14																			49.8	.55
58	792.1	9.47																			51.8	.56
60	847.7	9.79																			53.9	.56
62	905.2	10.12																			55.9	.56
64	964.5	10.45																			57.9	.56

RECTANG. BEAMS LIMITED BY CONCRETE	
M_1/M	%A_s
1.01	103
1.02	106
1.03	110
1.04	114
1.05	117
1.06	121
1.07	125
1.08	129
1.09	133
1.10	137
1.11	141
1.12	145
1.13	150
1.14	154
1.15	159
1.16	164
1.17	169
1.18	175
1.19	181
1.20	187
1.21	193
1.22	198
1.23	204
1.24	211
1.25	218
1.26	225
1.27	232
1.28	239
1.29	248
1.30	256



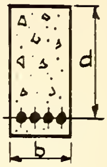
RECTANGULAR BEAMS
DESIGN CONSTANTS

$$k=\frac{nf_c}{nf_c+f_s} \text{ or } \frac{1}{1+(f_s\div nf_c)} \text{ or } \sqrt{2np+(np)^2}-np \text{ or } \frac{pf_s}{\frac{1}{2}f_c} \text{ or } \frac{2pn(1-k)}{k}$$

$$p=\frac{f_c}{2f_s}k \text{ or } \frac{1}{2}\frac{1}{\frac{f_s}{f_c}\left(\frac{f_s}{nf_c}+1\right)} \text{ or } \frac{k}{2}\frac{k}{(1-k)n} \text{ or } \frac{A_s}{bd}; \quad j=1-\frac{k}{3}; \quad jd=d-\frac{kd}{3}$$

$$R=f_spj \text{ or } \frac{1}{2}f_ckj \text{ or } f_c\left(\frac{k}{2}-\frac{k^2}{6}\right) \text{ or } \frac{M}{bd^2}; \quad f_s=\frac{nf_c(1-k)}{k}; \quad f_c=\frac{f_sk}{n(1-k)}$$

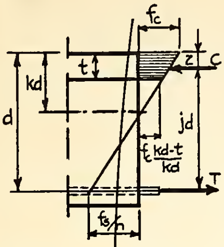
$$M=Rbd^2 \qquad M_c=\tfrac{1}{2}f_ckjbd^2 \text{ or } A_sf_sjd \qquad M_s=A_sf_sjd \text{ or } pf_sjbd^2$$



f_s	n = 15					n = 12					n = 10					f_s
	f_c	R	p	k	j	f_c	R	p	k	j	f_c	R	p	k	j	
12000	400	59.3	0.0056	0.333	0.889	500	74.1	0.0069	0.333	0.889	650	100.7	0.0095	0.351	0.883	12000
	450	71.3	0.0068	0.360	0.880	550	86.0	0.0081	0.355	0.882	700	113.3	0.0108	0.369	0.877	
	500	83.8	0.0080	0.385	0.871	600	98.4	0.0094	0.375	0.875	750	125.9	0.0120	0.385	0.872	
	550	96.8	0.0093	0.407	0.864	650	111.2	0.0107	0.394	0.869	800	138.7	0.0133	0.400	0.867	
	600	110.2	0.0107	0.429	0.857	700	124.3	0.0120	0.412	0.863	850	152.0	0.0147	0.415	0.862	
	650	123.9	0.0121	0.448	0.851	750	137.8	0.0134	0.429	0.857	900	165.1	0.0161	0.428	0.857	
	700	137.9	0.0136	0.467	0.844	800	151.4	0.0148	0.444	0.852	950	179.1	0.0175	0.442	0.853	
	750	151.9	0.0151	0.484	0.839	850	165.4	0.0163	0.459	0.847	1000	192.9	0.0190	0.455	0.848	
	800	166.7	0.0167	0.500	0.833	875	172.4	0.0171	0.467	0.844	1050	206.9	0.0204	0.467	0.844	
	850	181.3	0.0182	0.515	0.828	900	179.5	0.0178	0.474	0.842	1100	221.1	0.0219	0.478	0.841	
	900	196.2	0.0199	0.529	0.824	950	193.8	0.0193	0.487	0.838	1200	249.9	0.0250	0.500	0.833	
	950	211.2	0.0215	0.543	0.819	1000	208.3	0.0208	0.500	0.833	1300	279.5	0.0282	0.520	0.827	
	1000	226.3	0.0232	0.556	0.815	1125	245.2	0.0248	0.529	0.824	1350	294.4	0.0298	0.530	0.823	
14000	400	54.0	0.0043	0.300	0.900	500	67.5	0.0054	0.300	0.900	650	92.1	0.0074	0.317	0.894	14000
	450	65.3	0.0052	0.325	0.892	550	78.7	0.0063	0.320	0.893	700	103.6	0.0083	0.333	0.889	
	500	77.1	0.0062	0.349	0.884	600	90.4	0.0073	0.340	0.887	750	115.7	0.0093	0.349	0.884	
	550	89.4	0.0073	0.371	0.876	650	102.4	0.0083	0.358	0.881	800	128.0	0.0104	0.364	0.879	
	600	102.2	0.0084	0.391	0.870	700	114.9	0.0094	0.375	0.875	850	140.0	0.0114	0.377	0.874	
	650	115.2	0.0095	0.411	0.863	750	127.6	0.0105	0.391	0.870	900	153.1	0.0126	0.391	0.870	
	700	128.6	0.0107	0.429	0.857	800	140.7	0.0116	0.407	0.864	950	166.4	0.0138	0.405	0.865	
	750	142.3	0.0119	0.446	0.851	850	154.0	0.0128	0.421	0.860	1000	179.1	0.0149	0.416	0.861	
	800	156.2	0.0132	0.462	0.846	875	160.8	0.0134	0.429	0.857	1050	193.0	0.0161	0.429	0.857	
	850	170.4	0.0145	0.477	0.841	900	167.5	0.0140	0.435	0.855	1100	206.4	0.0173	0.440	0.853	
	900	184.8	0.0158	0.491	0.836	950	181.3	0.0152	0.449	0.850	1200	234.5	0.0198	0.462	0.846	
	950	199.3	0.0171	0.504	0.832	1000	195.3	0.0165	0.462	0.846	1300	262.9	0.0224	0.482	0.839	
	1000	214.0	0.0185	0.517	0.828	1125	232.3	0.0199	0.495	0.835	1350	277.1	0.0237	0.491	0.836	
16000	400	49.6	0.0034	0.273	0.909	500	62.5	0.0043	0.273	0.909	650	84.9	0.0059	0.289	0.904	16000
	450	60.2	0.0042	0.297	0.901	550	72.5	0.0050	0.292	0.903	700	95.7	0.0067	0.304	0.899	
	500	71.3	0.0050	0.319	0.894	600	83.5	0.0058	0.310	0.897	750	106.9	0.0075	0.319	0.894	
	550	83.0	0.0059	0.340	0.887	650	94.9	0.0067	0.328	0.891	800	118.4	0.0083	0.333	0.889	
	600	95.0	0.0068	0.360	0.880	700	106.7	0.0075	0.344	0.885	850	130.4	0.0092	0.347	0.884	
	650	107.5	0.0077	0.379	0.874	750	118.8	0.0084	0.360	0.880	900	142.6	0.0101	0.360	0.880	
	700	120.4	0.0087	0.396	0.868	800	131.3	0.0094	0.375	0.875	950	155.2	0.0111	0.373	0.876	
	750	133.5	0.0097	0.413	0.862	850	144.0	0.0103	0.389	0.870	1000	167.9	0.0120	0.385	0.872	
	800	146.9	0.0107	0.429	0.857	875	150.4	0.0108	0.396	0.868	1050	180.5	0.0130	0.396	0.868	
	850	160.6	0.0118	0.443	0.852	900	157.0	0.0113	0.403	0.866	1100	193.9	0.0140	0.408	0.864	
	900	174.5	0.0129	0.458	0.847	950	170.2	0.0123	0.416	0.861	1200	220.6	0.0161	0.429	0.857	
	950	188.6	0.0140	0.471	0.843	1000	183.7	0.0134	0.429	0.857	1300	248.1	0.0182	0.448	0.851	
	1000	202.9	0.0151	0.484	0.839	1125	218.2	0.0161	0.458	0.847	1350	261.9	0.0193	0.458	0.847	
18000	400	45.8	0.0028	0.250	0.917	500	57.3	0.0035	0.250	0.917	650	78.5	0.0048	0.265	0.912	18000
	450	55.8	0.0034	0.273	0.909	550	67.2	0.0041	0.268	0.911	700	88.9	0.0054	0.280	0.907	
	500	66.3	0.0041	0.294	0.902	600	77.6	0.0048	0.286	0.905	750	99.4	0.0061	0.294	0.902	
	550	77.4	0.0048	0.314	0.895	650	88.4	0.0055	0.302	0.899	800	110.3	0.0068	0.307	0.898	
	600	88.9	0.0056	0.333	0.889	700	99.6	0.0062	0.318	0.894	850	121.8	0.0076	0.321	0.893	
	650	100.8	0.0063	0.351	0.883	750	111.1	0.0069	0.333	0.889	900	133.2	0.0083	0.333	0.889	
	700	113.1	0.0072	0.368	0.877	800	123.0	0.0077	0.348	0.884	950	145.0	0.0091	0.345	0.885	
	750	125.7	0.0080	0.385	0.872	850	135.2	0.0085	0.362	0.879	1000	157.3	0.0099	0.357	0.881	
	800	138.7	0.0089	0.400	0.867	875	141.2	0.0089	0.368	0.877	1050	169.9	0.0108	0.369	0.877	
	850	151.9	0.0098	0.415	0.862	900	147.7	0.0094	0.375	0.875	1100	182.2	0.0116	0.379	0.874	
	900	165.3	0.0107	0.429	0.857	950	160.4	0.0102	0.388	0.871	1200	208.1	0.0133	0.400	0.867	
	950	179.0	0.0117	0.442	0.853	1000	173.3	0.0111	0.400	0.867	1300	234.8	0.0152	0.420	0.860	
	1000	192.8	0.0126	0.455	0.848	1125	206.6	0.0134	0.429	0.857	1350	248.2	0.0161	0.429	0.857	
20000	400	42.6	0.0023	0.231	0.923	500	53.3	0.0029	0.231	0.923	650	73.1	0.0040	0.245	0.918	20000
	450	52.0	0.0028	0.252	0.916	550	62.6	0.0034	0.248	0.917	700	82.9	0.0045	0.259	0.914	
	500	62.0	0.0034	0.273	0.909	600	72.4	0.0040	0.265	0.912	750	93.1	0.0051	0.273	0.909	
	550	72.5	0.0040	0.292	0.903	650	82.7	0.0046	0.281	0.906	800	103.5	0.0057	0.286	0.905	
	600	83.5	0.0047	0.310	0.897	700	93.1	0.0052	0.296	0.901	850	114.1	0.0063	0.298	0.901	
	650	94.9	0.0053	0.328	0.891	750	104.3	0.0058	0.310	0.897	900	125.1	0.0070	0.310	0.897	
	700	106.7	0.0060	0.344	0.885	800	115.7	0.0065	0.324	0.892	950	136.6	0.0077	0.322	0.893	
	750	118.8	0.0068	0.360	0.880	850	127.4	0.0072	0.338	0.887	1000	148.0	0.0083	0.333	0.889	
	800	131.2	0.0075	0.375	0.875	875	133.2	0.0075	0.344	0.885	1050	160.3	0.0091	0.345	0.885	
	850	144.0	0.0083	0.389	0.870	900	139.4	0.0079	0.351	0.883	1100	172.2	0.0098	0.355	0.882	
	900	157.0	0.0091	0.403	0.866	950	151.6	0.0086	0.363	0.879	1200	196.9	0.0113	0.375	0.875	
	950	170.2	0.0099	0.416	0.861	1000	164.1	0.0094	0.375	0.875	1300	222.6	0.0128	0.394	0.869	
	1000	183.7	0.0107	0.429	0.857	1125	196.2	0.0113	0.403	0.866	1350	235.6	0.0136	0.403	0.866	

TEE-BEAMS

DESIGN CONSTANTS—STEM COMPRESSION DISREGARDED



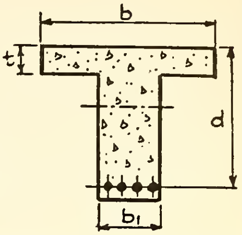
$$k=\frac{1}{1+(f_s\div nf_c)} \text{ or } \frac{pn+\frac{1}{2}(t\div d)^2}{pn+(t\div d)}; \qquad kd=\frac{2ndA_s+bt^2}{2nA_s+2bt}; \qquad jd=d-z$$

$$z=\frac{3kd-2t}{2kd-t}\left(\frac{t}{3}\right) \text{ or } d\left[k-\frac{t}{d}\left(\frac{3k-2(t\div d)}{6k-3(t\div d)}\right)\right]; \qquad j=\frac{6-6(t\div d)+2(t\div d)^2+(t\div d)^3\left(\frac{1}{2pn}\right)}{6-3(t\div d)}$$

$$R=f_c\frac{t}{d}\left(\frac{2k-(t\div d)}{2k}\right)\left[1-\frac{t}{d}\left(\frac{3k-2(t\div d)}{6k-3(t\div d)}\right)\right] \text{ or } \frac{M}{bd^2}; \qquad p=\frac{2k-(t\div d)}{2k}\left(\frac{t}{d}\right)\left(\frac{f_c}{f_s}\right) \text{ or } \frac{A_s}{bd}$$

$$M=Rbd^2; \qquad M_c=f_c\left(1-\frac{t}{2kd}\right)btjd \text{ or } \frac{2kd-t}{2kd}btjdf_c; \qquad M_s=A_sf_sjd$$

$$A_sf_s=\frac{2k-(t\div d)}{2k}f_cbt; \qquad f_c=\left(\frac{f_s}{n}\right)\frac{k}{1-k}; \qquad f_s=\frac{M}{A_sjd} \text{ or } \frac{f_cn(1-k)}{k}$$



f_s	$\frac{t}{d}$	n = 15									
		f_c=600		f_c=650		f_c=700		f_c=800		f_c=900	
		R	p	R	p	R	p	R	p	R	p
16000	.06	32	.0021	35	.0022	38	.0024	43	.0028	49	.0032
	.08	42	.0027	45	.0029	48	.0032	56	.0036	63	.0041
	.10	50	.0032	54	.0035	58	.0038	67	.0044	76	.0050
	.12	57	.0037	62	.0041	67	.0045	78	.0052	89	.0059
	.14	64	.0042	70	.0047	76	.0051	88	.0059	100	.0067
	.16	70	.0047	75	.0051	83	.0056	97	.0065	110	.0074
	.18	76	.0051	82	.0056	90	.0061	104	.0071	120	.0081
	.20	80	.0054	87	.0060	95	.0065	112	.0077	128	.0088
	.22	84	.0057	92	.0063	100	.0070	118	.0082	136	.0094
	.24	87	.0060	96	.0067	105	.0073	124	.0086	143	.0100
	.26	89	.0062	99	.0070	109	.0076	129	.0090	149	.0105
	.28	92	.0064	102	.0072	112	.0079	133	.0094	154	.0109
	.30	93	.0066	104	.0074	115	.0082	137	.0098	159	.0113
	.32	94	.0067	106	.0075	117	.0084	140	.0100	163	.0117
	.34	95	.0067	107	.0076	118	.0085	142	.0102	166	.0120
	.36	95	.0068	108	.0077	119	.0086	144	.0104	169	.0123
	.38					120	.0087	146	.0106	171	.0125
	.40							147	.0107	173	.0127
18000	.06	32	.0018	35	.0020	38	.0021	43	.0025	49	.0028
	.08	41	.0024	45	.0026	48	.0028	55	.0032	63	.0036
	.10	49	.0028	53	.0031	58	.0034	67	.0039	76	.0044
	.12	56	.0033	61	.0036	66	.0039	77	.0045	88	.0052
	.14	62	.0037	68	.0041	74	.0044	86	.0051	99	.0059
	.16	68	.0040	75	.0045	81	.0049	95	.0057	108	.0065
	.18	73	.0044	80	.0049	88	.0053	102	.0062	117	.0071
	.20	77	.0047	85	.0052	93	.0057	109	.0067	126	.0077
	.22	80	.0049	89	.0055	98	.0060	115	.0071	133	.0082
	.24	83	.0051	92	.0057	102	.0063	120	.0075	139	.0086
	.26	85	.0053	95	.0059	105	.0066	125	.0078	145	.0091
	.28	87	.0054	97	.0061	108	.0068	129	.0081	150	.0094
	.30	88	.0055	99	.0062	110	.0069	132	.0083	154	.0097
	.32	89	.0056	100	.0063	112	.0070	134	.0085	157	.0100
	.34			101	.0064	113	.0071	136	.0087	160	.0103
	.36					113	.0072	137	.0088	162	.0105
	.38							138	.0089	164	.0106
	.40							139	.0089	165	.0107
20000	.06	32	.0016	34	.0018	37	.0019	43	.0022	49	.0025
	.08	40	.0021	44	.0023	48	.0025	55	.0029	63	.0032
	.10	48	.0025	52	.0028	57	.0030	66	.0035	75	.0039
	.12	55	.0029	60	.0032	65	.0035	76	.0040	87	.0046
	.14	61	.0033	67	.0036	73	.0039	85	.0046	97	.0052
	.16	66	.0036	73	.0039	80	.0043	93	.0050	107	.0058
	.18	71	.0038	78	.0042	86	.0047	101	.0055	116	.0063
	.20	75	.0041	83	.0045	91	.0050	107	.0059	123	.0068
	.22	78	.0043	86	.0048	95	.0052	113	.0062	130	.0072
	.24	80	.0044	89	.0049	99	.0055	117	.0065	136	.0076
	.26	82	.0045	92	.0050	102	.0057	121	.0068	141	.0079
	.28	83	.0046	93	.0052	104	.0058	125	.0070	145	.0082
	.30	84	.0046	94	.0053	106	.0059	128	.0072	149	.0085
	.32			95	.0053	106	.0060	129	.0073	152	.0087
	.34					107	.0060	130	.0074	154	.0088
	.36							131	.0075	155	.0089
	.38									156	.0090
	.40									157	.0091

f_s	$\frac{t}{d}$	n = 12									
		f_c=650		f_c=750		f_c=875		f_c=1000		f_c=1125	
		R	p	R	p	R	p	R	p	R	p
16000	.06	34	.0022	40	.0026	48	.0030	54	.0035	61	.0040
	.08	44	.0029	52	.0033	60	.0039	70	.0045	79	.0052
	.10	53	.0034	62	.0040	72	.0048	84	.0055	95	.0063
	.12	60	.0040	71	.0047	84	.0056	87	.0065	110	.0074
	.14	67	.0045	79	.0053	95	.0064	110	.0074	125	.0084
	.16	73	.0049	87	.0059	104	.0070	121	.0082	138	.0093
	.18	78	.0053	93	.0063	112	.0076	131	.0089	151	.0102
	.20	83	.0056	99	.0068	119	.0082	140	.0096	161	.0110
	.22	87	.0059	104	.0072	125	.0088	148	.0103	170	.0118
	.24	89	.0062	108	.0075	131	.0092	155	.0108	179	.0125
	.26	92	.0064	111	.0078	136	.0096	161	.0113	186	.0131
	.28	93	.0065	114	.0080	140	.0099	166	.0117	193	.0136
	.30	94	.0066	116	.0082	144	.0102	171	.0121	199	.0141
	.32	95	.0067	118	.0083	146	.0104	175	.0124	204	.0146
	.34			119	.0084	147	.0106	178	.0127	208	.0150
	.36					148	.0107	180	.0130	211	.0154
	.38							181	.0132	214	.0156
	.40							181	.0133	216	.0158
18000	.06	34	.0020	39	.0023	47	.0026	54	.0031	61	.0035
	.08	44	.0025	51	.0030	60	.0035	69	.0040	78	.0045
	.10	52	.0030	61	.0036	72	.0042	83	.0049	95	.0055
	.12	59	.0035	70	.0041	83	.0049	96	.0057	110	.0065
	.14	66	.0039	78	.0046	93	.0055	108	.0064	123	.0074
	.16	71	.0043	85	.0051	102	.0061	119	.0071	136	.0081
	.18	76	.0046	91	.0055	109	.0066	128	.0078	147	.0088
	.20	80	.0048	96	.0058	117	.0071	136	.0084	157	.0096
	.22	83	.0051	100	.0061	122	.0075	144	.0089	166	.0103
	.24	85	.0052	104	.0064	127	.0079	151	.0094	174	.0108
	.26	87	.0053	107	.0066	132	.0083	156	.0098	181	.0113
	.28	88	.0054	109	.0068	135	.0085	161	.0101	188	.0118
	.30	88	.0055	110	.0069	138	.0086	165	.0104	193	.0122
	.32			111	.0069	140	.0088	168	.0106	197	.0125
	.34					141	.0089	171	.0108	201	.0128
	.36					142	.0090	172	.0110	203	.0131
	.38							173	.0111	205	.0133
	.40							173	.0111	206	.0134
20000	.06	34	.0017	40	.0020	47	.0024	54	.0028	61	.0031
	.08	43	.0022	50	.0026	60	.0031	69	.0036	78	.0040
	.10	51	.0027	60	.0032	71	.0038	83	.0043	94	.0049
	.12	58	.0031	69	.0036	82	.0043	95	.0050	108	.0057
	.14	64	.0034	76	.0041	91	.0049	107	.0057	122	.0065
	.16	69	.0037	83	.0045	100	.0054	117	.0063	134	.0072
	.18	73	.0040	89	.0048	107	.0058	126	.0068	144	.0079
	.20	77	.0042	94	.0051	113	.0062	134	.0073	154	.0085
	.22	79	.0043	98	.0053	118	.0065	141	.0078	163	.0090
	.24	81	.0045	100	.0055	123	.0068	147	.0082	170	.0095
	.26	82	.0045	102	.0057	127	.0071	152	.0085	176	.0099
	.28	82	.0046	104	.0058	130	.0072	156	.0088	182	.0103
	.30			105	.0058	132	.0074	160	.0090	186	.0106
	.32					133	.0075	161	.0092	190	.0108
	.34					133	.0075	163	.0093	193	.0110
	.36							164	.0094	195	.0112
	.38									196	.0113
	.40									196	.0113

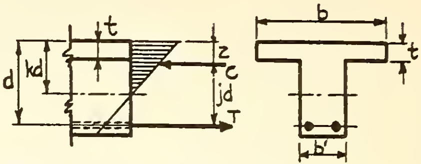
f_s	$\frac{t}{d}$	n = 10									
		f_c=750		f_c=900		f_c=1050		f_c=1200		f_c=1350	
		R	p	R	p	R	p	R	p	R	p
16000	.06	40	.0025	48	.0032	57	.0036	65	.0042	73	.0047
	.08	51	.0033	63	.0041	72	.0048	84	.0054	94	.0062
	.10	60	.0040	75	.0049	87	.0059	100	.0066	114	.0075
	.12	69	.0046	86	.0056	100	.0068	117	.0077	133	.0087
	.14	77	.0051	96	.0063	114	.0077	132	.0088	150	.0099
	.16	84	.0056	105	.0070	125	.0085	145	.0098	165	.0112
	.18	89	.0061	114	.0076	135	.0092	156	.0107	180	.0122
	.20	94	.0065	120	.0081	143	.0098	168	.0115	192	.0131
	.22	98	.0068	126	.0085	150	.0104	177	.0122	204	.0140
	.24	102	.0070	131	.0089	157	.0109	186	.0128	215	.0148
	.26	104	.0072	134	.0093	164	.0114	194	.0134	224	.0156
	.28	106	.0073	138	.0096	168	.0118	200	.0140	231	.0163
	.30	107	.0074	140	.0098	172	.0122	206	.0145	238	.0169
	.32			141	.0100	175	.0125	210	.0149	245	.0175
	.34			142	.0101	177	.0128	213	.0153	249	.0180
	.36			142	.0102	179	.0129	216	.0156	253	.0184
	.38					180	.0130	219	.0158	256	.0187
	.40							220	.0160	258	.0190
18000	.06	39	.0022	48	.0027	56	.0032	65	.0037	73	.0042
	.08	50	.0029	61	.0035	72	.0042	83	.0048	94	.0055
	.10	60	.0035	73	.0043	87	.0051	100	.0058	113	.0066
	.12	68	.0040	84	.0049	100	.0059	116	.0068	132	.0078
	.14	75	.0045	93	.0055	111	.0066	130	.0077	148	.0088
	.16	82	.0049	102	.0061	122	.0073	143	.0085	163	.0098
	.18	87	.0052	109	.0066	131	.0080	154	.0093	176	.0107
	.20	91	.0055	115	.0070	140	.0085	164	.0100	188	.0115
	.22	95	.0057	120	.0074	147	.0090	173	.0106	199	.0123
	.24	97	.0059	125	.0077	153	.0095	181	.0112	209	.0130
	.26	98	.0060	128	.0079	158	.0098	188	.0117	218	.0136
	.28	99	.0061	131	.0081	162	.0102	193	.0122	225	.0142
	.30			132	.0082	165	.0104	198	.0125	231	.0146
	.32			133	.0083	168	.0106	202	.0128	236	.0151
	.34					169	.0107	205	.0130	241	.0154
	.36					170	.0108	206	.0132	244	.0157
	.38							207	.0133	246	.0159
	.40							208	.0133	247	.0160
20000	.06	39	.0020	48	.0024	56	.0029	64	.0033	73	.0038
	.08	49	.0026	60	.0031	72	.0037	82	.0043	94	.0049
	.10	58	.0031	72	.0038	86	.0045	99	.0052	113	.0059
	.12	66	.0035	83	.0044	98	.0052	114	.0061	130	.0069
	.14	73	.0039	92	.0049	109	.0059	128	.0068	146	.0078
	.16	79	.0042	99	.0053	120	.0065	140	.0076	161	.0087
	.18	84	.0045	106	.0057	129	.0070	151	.0082	174	.0095
	.20	87	.0048	112	.0061	137	.0074	161	.0088	185	.0101
	.22	90	.0049	117	.0064	143	.0079	169	.0093	195	.0108
	.24	92	.0050	120	.0066	148	.0082	176	.0098	204	.0114
	.26	93	.0051	123	.0068	152	.0085	182	.0102	211	.0119
	.28			124	.0069	156	.0087	187	.0105	218	.0123
	.30			126	.0070	158	.0089	192	.0108	224	.0127
	.32					159	.0090	194	.0110	228	.0130
	.34					160	.0090	196	.0112	231	.0133
	.36							197	.0112	233	.0134
	.38									234	.0135
	.40									235	.0136

REINFORCED CONCRETE BEAMS

DESIGN DATA

TEE BEAMS.

Compression in Stem Considered:



When f_c and f_s are known, the method of determining size of beam and amount of reinforcing as shown in Example 8, Explanation of Universal Beam Tables will prove much simpler, and will give exact results.

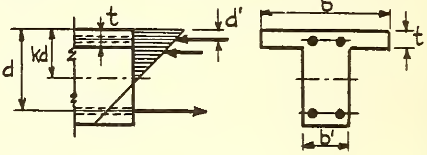
$$kd = \sqrt{\frac{2nd\,A_s + (b-b')t^2}{b'} + \left(\frac{n\,A_s + (b-b')t}{b'}\right)^2} - \frac{n\,A_s + (b-b')t}{b'}$$

$$z = \frac{(kdt^2 - 0.667t^3)b + [(kd-t)^2\ (t + 0.333(kd-t))]b'}{t(2kd-t)b + (kd-t)^2 b'}$$

$$f_c = \frac{2Mkd}{[(2kd-t)bt + (kd-t)^2 b']jd} \qquad f_s = \frac{M}{A_s jd};\quad M_s = A_s f_s jd;\quad jd = d - z$$

$$M_c = \frac{f_c}{2kd}[(2kd-t)bt + (kd-t)^2 b\ ]jd$$

With Compression Reinforcement:



When both depth and flange width of a Tee beam are limited, compressive stresses of an excessive amount may be provided for by using compression steel in the upper portion of the beam. The neutral axis is unaffected for specified values of f_c and f_s. With d, b, b' and t known for a given moment, the total tensile and compression steel are found:

M = Total Bending Moment in beam.
M_T = Bending Moment of balanced design Tee beam.
M_1 = Moment to be carried by compression steel, total, $= M - M_T$
M_c = Resisting Moment value of one sq. in. compression steel.
A'_s = Area compression steel, $= M_1 \div M_c$.

$$M_c = f_c(n-1)\left(1 - \frac{d'}{kd}\right)(d-d').$$

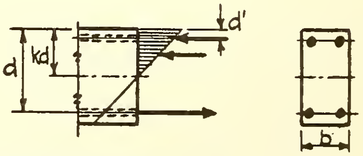
A_{ST} = Total area tensile steel, $= A_s + A_{sc}$.

$$A_{sc} = \frac{M_1}{f_s(d-d')}$$

$$R = \frac{M}{bd^2} = f_c\left\{\frac{t}{d}\left(\frac{2k - \frac{t}{d}}{2k}\right)\left[1 - \frac{t}{d}\left(\frac{3k - 2\frac{t}{d}}{6k - 3\frac{t}{d}}\right)\right] + \left(\frac{n-1}{k}\right)p'\left[(1-k)\left(k - \frac{d'}{d}\right) + \left(k - \frac{d'}{d}\right)^2\right]\right\}$$

RECTANGULAR BEAMS.

With Compression Reinforcement:



When depth and width of a rectangular beam are fixed and the moment to be carried produces excessive concrete compressive stresses, compression steel may be used as above, for Tee beams. The neutral axis, and therefore k and j, are unaffected.

M = Total Bending Moment in beam.
M_R = Bending Moment of balanced design Rectangular beam.
M_1 = Moment to be carried by compression steel, total, $= M - M_R$
M_c = Resisting Moment value of one sq. in. compression steel.
A'_s = Area compression steel, $= M_1 \div M_c$.

$$M_c = f_c(n-1)\left(1 - \frac{d'}{k\,d}\right)(d-d').$$

A_{SR} = Total area tensile steel, $= A_s + A_{sc}$.

$$A_{sc} = \frac{M_1}{f_s(d-d')}$$

$$R = \frac{M}{bd^2} = f_c\left\{\frac{k}{2} - \frac{k^2}{6} + \frac{n-1}{k}p'\left[(1-k)\left(k - \frac{d'}{d}\right) + \left(k - \frac{d'}{d}\right)^2\right]\right\}$$

Unbalanced Design; Size Limited by Conc. Compression:

In a rectangular beam of balanced design, both steel and concrete are stressed to their working limits simultaneously. When the beam is limited in size and the concrete compression exceeds the allowable, steel in compression is generally added.

Another method of achieving the result is by increasing the amount of tensile steel only. In any beam, the neutral axis has a fixed position for given values of b, d, n and A_s, and the ratio of maximum unit stresses in steel and concrete is constant for these values. From this it follows that any change in A_s will affect the position of the neutral axis, and thus an increase in A_s will enlarge the area available for compression in the concrete by lowering the axis; this total compression of course balancing the tension in the steel.

This lowering of the neutral axis will decrease the unit stress in the enlarged steel area, A_s, and the design is not economical for this reason. However, it is often desirable to use this means of maintaining a given beam size.

The distance from the extreme fiber in compression to the neutral axis, kd, must be found, such that it will produce a total compressive area with the limits of the design requirements.

Example:

Assume a 12″x20″ beam; $M = 591000$ in. lbs; $f_c = 700$; $f_s = 18000$; $n = 15$.

The total compression, $C = \frac{f_c}{2} bkd$.

$$= 4200\,kd.$$

$$C_{jd} = 4200\,kd\,(d - \frac{kd}{3}) = M$$

$$= 4200\,kd\,(20 - \frac{kd}{3}) = 591{,}000$$

Solving for kd,

$$1400\,kd\,(60 - kd) = 591{,}000$$

$$kd\,(60 - kd) = 422$$

$$60\,kd - kd^2 = 422$$

$$kd = \frac{60 \pm \sqrt{3600 - 4 \times 422}}{2}$$

$$= \frac{60 - 43.7}{2}$$

$$= 8.15$$

$$jd = d - \frac{kd}{3}$$

$$= 17.28$$

$$C = T = \frac{591000}{17.28} = 34{,}200$$

$$f_s = n\left(f_c \frac{d - kd}{kd}\right)$$

$$= 15\left(700 \frac{20 - 8.15}{8.15}\right)$$

$$= 15250$$

$$A_s = \frac{34200}{15250} = 2.24\square''$$

GENERAL NOTES.

In the design of reinforced concrete members, the following generally accepted assumptions are made:

(*a*) Calculations are based on working stresses rather than ultimate strengths.
(*b*) A plane section before bending remains plane after bending.
(*c*) The modulus of elasticity of concrete in compression is constant within the limits of the working stresses.
(*d*) The distribution of compressive stress in beams is rectilinear.
(*e*) Tension in the concrete is neglected.
(*f*) The bond between concrete and metal reinforcing remains unbroken throughout the range of working stress.
(*g*) Initial stress in the reinforcement due to contraction or expansion of the concrete is neglected.

The modulus of elasticity of concrete is not constant, being a maximum for small stresses near the neutral axis and decreasing for larger stresses. It is also affected greatly by the time element and plastic flow.

Shrinkage in concrete extending over a period of time will unquestionably affect the assumptions made in (*f*) and (*g*), but while the fundamental theories of concrete design do not respond to actual analysis, the generally accepted assumptions have sufficed.

EXPLANATION OF UNIVERSAL STIRRUP TABLES

The computation of stirrup size and spacing as shear reinforcing to resist diagonal tension is often the most lengthy and laborious portion of the design of reinforced concrete beams. By the use of the Universal Stirrup Tables a vast amount of time is saved and the work is greatly simplified. The spacing of stirrups by this method is applicable to

1. Beams with uniform loads.
2. Beams with concentrated loads.
3. Beams with both uniform and concentrated loads.

The theory used is based upon the plain concrete taking a definite amount of diagonal tension, with the stirrups taking the balance. The tables are based on the formulae:

$$A_v = \frac{\frac{V}{jd} - v_c b}{f_s}\ .5 \quad \text{and} \quad s = \frac{A_s f_s}{\frac{V}{jd} - v_c b} \qquad \text{for vertical stirrups.}$$

The nomenclature used:

A_v = Area of shear reinforcing.
V = Total shear on section.
v = Total unit shear on section, lbs. sq. in.
v_c = Unit shear carried by concrete.
v_s = Unit shear carried by stirrups.
v_u = Value of one stirrup for given spacing.
v_x = Change in unit shear, v, per foot.
s = Spacing of stirrups, inches
a = Length, in inches, for given stirrup spacing.
K = Constant for given beam width, size stirrup bar and fiber stress.

Typical examples will best illustrate the use of the tables.

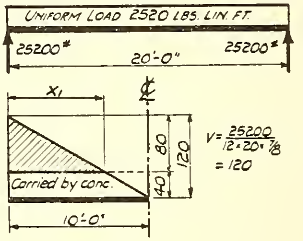
1. BEAM WITH UNIFORM LOAD.

Assume 12″x22″ beam (eff. depth 20″); span 20′-0″; $V = 25200\#$; $v = 120$; $v_c = 40$; $v_s = 80$.

Referring to Table 1, "Values of Stirrups", for $\frac{3}{8}\phi$ stirrups, 12″ beam width, K will be found to be 293. Value of $v_s = v - v_c = 120 - 40 = 80$. The first spacing would be $\frac{K}{v_s} = \frac{293}{80} = 3.67''$. This will govern the first series of spacings.

Next referring to Table 2, "Change in Unit Shear per foot and length requiring Stirrups", for $v = 120$ and span of 20′-0″, we find $v_x = 12$ and $x_1 = 80''$.

Next assume desired basic spacing. As mentioned, the first series is governed by $\frac{K}{v_s}$ of 3.67″ for which 4″ will suffice. We will therefore assume multiples of 4″ — 6″ — 9″ — 12″.


UNIFORM LOAD 2520 LBS. LIN. FT.
25200#
25200#
20′-0″
x_1
℄
80
120
40
Carried by conc.
10′-0″
$V = \frac{25200}{12 \times 20 \times \frac{7}{8}}$
$= 120$

Referring again to Table 1, for 12″ beam and $\frac{3}{8}\phi$ stirrups, and considering distance "a" to point where considered spacing stops and next spacing begins, we find values of "v_u" as follows:

For 4″ spacing, point where 6″ spac. begins, $v_u = 49$ and $v_s - v_u = 80 - 49 = 31$
For 6″ spacing, point where 9″ spac. begins, $v_u = 33$ and $v_s - v_u = 80 - 33 = 47$
For 9″ spacing, point where 12″ spac. begins, $v_u = 24$ and $v_s - v_u = 80 - 24 = 56$

We have already found the shear variation, "v_x", to be 12. Now referring to Table 3, "Lengths required for given spacing", under proper values of "v_x" and "$v_s - v_u$" we find

Distance "a" for 4″ spacing, point where 6″ spac. begins, = 31″
Point where 9″ spac. begins, = 47″
Point where 12″ spac. begins, = 56″

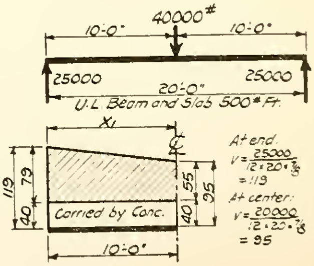
Therefore,

4″ stirrups spacing required for distance of 31″ = 31″ or 7 @ 4″
6″ stirrups spacing required for distance of 47 — 31 = 16″ or 3 @ 6″
9″ stirrups spacing required for distance of 56 — 47 = 9″ or 1 @ 9″
12″ stirrups spacing required for distance of 80 — 56 = 24″ or 2 @ 12″

2. BEAM WITH CONCENTRATED LOAD.

Assume 12″x22″ beam (20″ eff. depth); span 20′-0″; concentrated load at center 40000#; weight beam and slab 500# lin. ft. Shears as shown.

Assume $\frac{3}{8}\phi$ stirrups. For 12″ beam width, Table 1, gives $K = 293$. $\frac{K}{v_s} = \frac{293}{79} = 3.7''$. Since Table 2 applies only for uniform loads, both v_x and x_1 must be computed. With $v = 119$ @ support and 95 @ center (critical), $v_x = \frac{119 - 95}{10} = 2.4$. It is evident stirrups must be used full length of beam.


40000#
10′-0″
10′-0″
25000
25000
20′-0″
U.L. Beam and Slab 500# Ft.
x_1
℄
119
79
40
Carried by Conc.
55
95
40
10′-0″
At end.
$V = \frac{25000}{12 \times 20 \times \frac{7}{8}}$
$= 119$
At center:
$V = \frac{20000}{12 \times 20 \times \frac{7}{8}}$
$= 95$

Assume 4″ spacing to start. From Table 1, next spacing (5″) gives value of "v_u" = 59. With "v_s" = 79 as already found, the value of $v_s - v_u$ becomes $79 - 59 = 20$. With change in unit shear per foot = $v_x = 2.4$, the distance "*a*" from Table 3 for these values is 104″; the distance requiring 4″ spacing. Since the half span length under consideration is but 10′-0″ or 120″, the spacing of 4″ will be used throughout,, without change.

3. BEAM WITH BOTH CONCENTRATED AND UNIFORM LOADS.

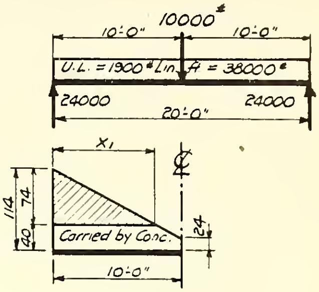
Assume 12″x22″ beam (20″ eff. depth); span 20′ 0″; concentrated load of 10000 # at center; uniform load, including weight of beam of 1900 # per lineal foot.

The uniform load produces no shear at center; the unit shear at that point is induced by one-half the concentrated load and is

$$\frac{.5 \times 10000}{12 \times 20 \times \frac{7}{8}} = 24 \#$$

The reaction, or shear at support is one-half the total uniform load plus one-half the concentrated load, or a total of 24000 #. Unit shear

$$\frac{24000}{12 \times 20 \times \frac{7}{8}} = 114 \#$$



With these values:

$$v_s = 114 - 40 = 74; \quad v_x = \frac{114 - 24}{10} = 9; \quad x_1 = \frac{114 - 40}{9} = 8.2' \text{ or } 99''.$$

Assume 4″ — 6″ — 9″ — 12″ spac.

From Table 1:

For 4″ spacing, point where 6″ spac. begins, $v_u = 49$ and $v_s - v_u = 74 - 49 = 25$
For 6″ spacing, point where 9″ spac. begins, $v_u = 33$ and $v_s - v_u = 74 - 33 = 41$
For 9″ spacing, point where 12″ spac. begins, $v_u = 24$ and $v_s - v_u = 74 - 24 = 50$

From Table 3:

Distance "*a*" to point where 6″ spac. begins = 34″
Distance "*a*" to point where 9″ spac. begins = 54″
Distance "*a*" to point where 12″ spac. begins = 67″

Therefore:

4″ spacing required for distance of 34″
6″ spacing required for distance of 54 — 34 = 20″
9″ spacing required for distance of 67 — 54 = 13″
12″ spacing required for distance of 99 — 67 = 32″ Continue 12″ spac. to center.

GENERAL.

A beam with any number of concentrated loads, or combinations of concentrated and uniform loads, may be easily solved by breaking up into separate component parts of triangular or trapezoidal form. It is then necessary but to calculate the change in shear per foot, and the distance x_1 requiring stirrups. It is not feasible to tabulate these values for trapezoidal shear diagrams. They are given in the tables, however, for triangular shear diagrams, for beams with uniform loads.

The maximum stirrup spacing tabulated is 12″. Since the spacings are in direct ratio to the constant *K*, and to each other, for any given size stirrup, width of beam, and fiber stress, any spacing not shown may be quickly found. For instance, the value of "v_u" for a 12″ beam, ⅜φ stirrups, 24″ spacing, is half the value given for 12″ spacing. The value given for 4½″ spacing is twice that given for a 9″ spacing, and so on.

The maximum size stirrup bar shown is ½φ. Larger sizes may be used by computing a new value of *K* for the larger stirrup size. The constant *K* is

$$K = \frac{A_s f_s}{b} \text{ and for a given spacing, } v_u = \frac{K}{s} \text{ and } s = \frac{K}{v_u}$$

In general, when the unit shearing stress does not exceed $0.06f'_c$, the distance between adjacent stirrups, measured perpendicularly to the direction of stirrup, should not exceed $0.75d$; when unit shearing stress exceeds $0.06f'_c$ the spacing shall not exceed $0.375d$.

The maximum diameter stirrup bar permissable in a beam is in direct relation to the effective depth. The "Handbook of Reinforced Concrete Building Design", of the American Concrete Institute gives data for concrete of various strengths. A widely used assumption is that the stirrup bar diameter shall not exceed 1/50 of the effective depth.

V = Total unit shear on section.
V_c = Unit shear carried by concrete.
V_s = Unit shear carried by stirrups.
V_u = Value of stirrup for given spacing.
V_x = Change in unit shear, V, per foot.

UNIVERSAL STIRRUP TABLES

FOR REINFORCED CONCRETE BEAMS

$f_s = 16000$

1.—VALUE OF STIRRUPS

"b" BEAM WIDTH	1/4 ⌀										3/8 ⌀										1/2 ⌀									
	K	VALUES OF "Vu" FOR SPACING IN INCHES									K	VALUES OF "Vu" FOR SPACING IN INCHES									K	VALUES OF "Vu" FOR SPACING IN INCHES								
		3″	4″	5″	6″	7″	8″	9″	10″	12″		3″	4″	5″	6″	7″	8″	9″	10″	12″		3″	4″	5″	6″	7″	8″	9″	10″	12
8	200	67	50	40	33	29	25	22	20	17	440			88	73	63	55	49	44	37	785							87	79	65
10	160	53	40	32	27	23	20	18	16	13	352		88	71	59	50	44	39	35	29	628					90	79	70	63	52
12	133	45	33	27	22	19	17	15	13	11	293	98	73	59	49	42	37	33	29	24	523				87	75	65	58	52	44
14	114	38	29	23	19	16	14	13	11	10	252	84	63	50	42	36	31	28	25	21	448			90	75	64	56	50	45	37
16	100	33	25	20	17	14	13	11	10	8	220	73	55	44	37	31	28	25	22	18	392		98	79	65	56	49	44	39	33
18	89	30	22	18	15	13	11	10	9	7	196	65	49	39	33	28	25	22	20	16	348		87	70	58	50	44	39	35	29
20	80	27	20	16	13	11	10	9	8	7	176	59	44	35	29	25	22	20	18	15	314		79	63	52	45	39	35	31	26
22	73	24	18	15	12	10	9	8	7	6	160	53	40	32	27	23	20	18	16	13	285	95	71	57	48	41	36	32	29	24
24	67	22	17	13	11	10	8	7	7	6	147	49	37	29	24	21	18	16	15	12	261	87	65	52	44	37	33	29	26	22

2.—CHANGE IN UNIT SHEAR PER FOOT, AND LENGTH REQUIRING STIRRUPS

V	SPAN OF BEAM, IN FEET																																					
	10′		11′		12′		13′		14′		15′		16′		18′		20′		22′		24′		26′		28′		30′		32′		34′		36′		38′		40′	
	V_x	X_1	V_x	X_1	V_x	X_1	V_x	X_1	V_x	X_1	V_x	X_1	V_x	X_1	V_x	X_1	V_x	X_1	V_x	X_1	V_x	X_1	V_x	X_1	V_x	X_1	V_x	X_1	V_x	X_1	V_x	X_1	V_x	X_1	V_x	X_1	V_x	X_1
120	24	40	22	44	20	48	19	52	17	56	16	60	15	64	13	72	12	80	11	88	10	96	9	104	9	112	8	120	8	128	7	136	7	144	6	152	6	160
115	23	39	21	43	19	47	18	51	16	55	15	59	14	63	13	70	12	78	11	86	10	94	9	102	8	109	8	117	7	125	7	133	6	141	6	148	6	156
110	22	38	20	42	18	46	17	50	16	53	15	57	14	61	12	69	11	76	10	84	9	91	8	99	8	107	7	115	7	122	6	130	6	137	6	145	6	153
105	21	37	19	41	18	45	16	48	15	52	14	56	13	59	12	67	11	74	10	82	9	89	8	96	8	104	7	111	7	119	6	126	6	134	6	141	5	148
100	20	36	18	40	17	43	15	47	14	51	13	54	13	58	11	65	10	72	9	79	8	86	8	94	7	101	7	108	6	115	6	122	6	130	5	137	5	144
95	19	35	17	38	16	42	15	45	14	49	13	52	12	56	11	63	10	69	9	76	8	83	7	90	7	97	6	104	6	111	6	118	5	125	5	132	5	139
90	18	33	16	37	15	40	14	43	13	47	12	50	11	53	10	60	9	67	8	73	8	80	7	87	6	93	6	100	6	107	5	113	5	120	5	127	5	133
85	17	32	16	35	14	38	13	41	12	45	11	48	11	51	9	57	9	64	8	70	7	76	7	83	6	89	6	95	5	102	5	108	5	114	4	120	4	127
80	16	30	15	33	13	36	12	39	11	42	11	45	10	48	9	54	8	60	7	66	7	72	6	78	6	84	5	90	5	96	5	102	4	108	4	114	4	120
75	15	28	14	31	13	34	12	36	11	39	10	42	9	45	8	50	8	56	7	62	6	67	6	73	5	78	5	84	5	90	4	95	4	101	4	106	4	112
70	14	26	13	28	12	31	11	34	10	36	9	39	9	41	8	46	7	51	6	57	6	62	5	66	5	72	5	77	4	82	4	87	4	93	4	98	4	103
65	13	23	12	25	11	28	10	30	9	32	9	35	8	37	7	41	7	46	6	51	5	55	5	60	5	65	4	69	4	74	4	78	4	83	3	88	3	92
60	12	20	11	22	10	24	9	26	9	28	8	30	8	32	7	36	6	40	5	44	5	48	5	52	4	56	4	60	4	64	4	68	3	72	3	76	3	80
55	11	16	10	18	9	20	8	21	8	23	7	25	7	26	6	29	6	33	5	36	5	39	4	43	4	46	4	49	3	52	3	56	3	59	3	62	3	65
50	10	12	9	13	8	14	8	16	7	17	7	18	6	19	6	22	5	24	5	26	4	29	4	31	4	34	3	36	3	39	3	41	3	43	3	46	3	48

3.—LENGTH REQUIRED FOR GIVEN SPACING

$V_s - V_u$	LENGTH "A" FOR VALUES OF "Vx" SHOWN																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
2	24	12	8	6	5	4	3	3	3	2														
4	48	24	16	12	10	8	7	6	5	5	4	4	4											
6	72	36	24	18	14	12	10	9	8	7	7	6	6	5	5	5	4							
8	96	48	32	24	19	16	14	12	11	10	9	8	7	7	6	6	6	5	5	5				
10	120	60	40	30	24	20	17	15	13	12	11	10	9	9	8	8	7	7	6	6	6	5	5	
12	144	72	48	36	29	24	21	18	16	14	13	12	11	10	10	9	8	8	8	7	7	7	6	6
14	168	84	56	42	34	28	24	21	19	17	15	14	13	12	11	10	10	9	9	8	8	8	7	7
16	192	96	64	48	38	32	27	24	21	19	17	16	15	14	13	12	11	11	10	10	9	9	8	8
18	216	108	72	54	43	36	31	27	24	22	20	18	17	15	14	13	13	12	11	11	10	10	9	9
20	240	120	80	60	48	40	34	30	27	24	22	20	18	17	16	15	14	13	13	12	11	11	10	10
22	264	132	88	66	53	44	38	33	29	26	24	22	20	19	18	17	16	15	14	13	13	12	11	11
24	288	144	96	72	58	48	41	36	32	29	26	24	22	21	19	18	17	16	15	14	14	13	13	12
26		156	104	78	62	52	45	39	35	31	28	26	24	22	21	20	18	17	16	16	15	14	14	13
28		168	112	84	67	56	48	42	37	34	31	28	26	24	22	21	20	19	18	17	16	15	15	14
30		180	120	90	72	60	51	45	40	36	33	30	28	26	24	23	21	20	19	18	17	16	16	15
32		192	128	96	77	64	55	48	43	38	35	32	30	27	26	24	23	21	20	19	18	17	17	16
34			136	102	82	68	58	51	45	41	37	34	31	29	27	26	24	23	22	20	19	18	18	17
36				108	87	72	62	54	48	43	39	36	33	31	29	27	25	24	23	22	21	20	19	18
38				114	91	76	65	57	51	46	41	38	35	33	30	29	27	25	24	23	22	21	20	19
40				120	96	80	69	60	53	48	44	40	37	34	32	30	28	27	25	24	23	22	21	20
42					101	84	72	63	56	50	46	42	39	36	34	32	30	28	27	25	24	23	22	21
44					106	88	76	66	59	53	48	44	41	38	35	33	31	29	28	26	25	24	23	22
46					110	92	79	69	61	55	50	46	43	39	37	35	33	31	29	28	26	25	24	23
48					115	96	82	72	64	58	52	48	44	41	38	36	34	32	30	29	28	26	25	24
50						100	86	75	67	60	55	50	46	43	40	38	35	33	32	30	29	27	26	25
52						104	89	78	69	62	57	52	48	45	42	39	37	35	33	31	30	28	27	26
54						108	93	81	72	65	59	54	50	46	43	41	38	36	34	32	31	29	28	27
56						112	96	84	75	67	61	56	52	48	45	42	40	37	35	34	32	31	29	28
58							100	87	77	70	63	58	54	50	46	44	41	39	37	35	34	32	30	29
60							103	90	80	72	66	60	56	52	48	46	42	40	38	36	34	33	31	30
62							106	93	83	74	68	62	57	53	50	47	44	41	39	37	35	34	32	31
64							110	96	85	77	70	64	59	55	51	48	45	43	41	38	37	35	33	32
66								99	88	79	72	66	61	57	53	50	47	44	42	40	38	36	34	33
68								102	91	82	74	68	63	58	54	51	48	45	43	41	39	37	35	34
70								105	93	84	76	70	65	60	56	53	49	47	44	42	40	38	37	35
72								108	96	86	79	72	67	62	58	54	51	48	45	43	41	39	38	36
74									99	89	81	74	68	64	59	56	52	49	47	44	42	40	39	37
76									101	91	83	76	70	65	61	57	54	51	48	46	43	42	40	38
78									104	94	85	78	72	67	62	59	55	52	49	47	45	43	41	39
80									107	96	87	80	74	69	64	60	56	53	51	48	46	43	42	40
85										102	93	85	79	73	68	64	60	57	54	51	49	46	43	42
90										108	98	90	83	77	72	68	64	60	57	54	52	49	47	45

REINFORCED CONCRETE SLABS

UNIVERSAL LOAD TABLES

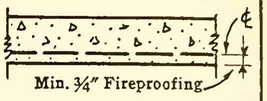
The tabulated Allowable Loads are for superimposed loads only, not including weight of slab. Example: Find depth of slab and area of steel required for superimposed load of 100 #/□′ on 10′-0″ continuous span (1/12 factor). From inspection a 4½″ slab is good for 110 #/□′ with A_s of 0.30□″. The required steel area will be

$$[(100 + 56) \div (110 + 56)] \times .30 = .282□''.$$

If it is desired to use a 5″ slab the area of steel required would be

$$[(100 + 63) \div (154 + 63)] \times .34 = .255□''.$$

Note that weight of slab must be added to allowable superimposed loads in computations.



$f_s = 18000$
$f_c = 700$
$n = 15$

TOTAL THICKNESS OF SLAB	LBS. SLAB PER SQ. FT.	CU. FOOT VOL. CONC. PER SQ. FT.	AREA STEEL A_s	MOMENT FACTOR	1′6″	2′	2′6	3′	3′6	4′	4′6	5′	6′	7′	8′	9′	10′	11′	12′	13′	14′	15′	16′	17′	18′
2″	25	.167	.09	1/8	378	201	120	75																	
				1/10	478	258	156	100																	
				1/12	578	315	192	126																	
2½″	31	.208	.13	1/8	875	477	294	195	135	96															
				1/10	1100	604	375	251	176	128															
				1/12	1321	731	457	308	218	159															
3″	38	.25	.17	1/8		867	540	364	257	188	141	106	62	36	18										
				1/10		1092	685	464	331	244	185	143	87	54	33										
				1/12		1322	832	564	406	301	230	179	112	73	47										
3½″	44	.292	.21	1/8				585	418	310	236	182	113	71	44	26									
				1/10				741	533	398	306	239	153	100	66	43									
				1/12				900	650	486	376	295	192	129	88	61									
4″	50	.333	.26	1/8				855	615	460	352	275	176	116	77	50	31								
				1/10				1080	780	586	452	357	233	158	109	75	52								
				1/12				1306	947	713	553	438	290	199	141	100	72								
4½″	56	.375	.30	1/8						637	492	387	252	170	117	81	55	36							
				1/10						810	629	499	329	227	160	115	82	58							
				1/12						984	784	609	406	283	204	149	110	81							
5″	63	.417	.34	1/8						842	652	517	340	233	163	116	82	57	37						
				1/10						1067	831	661	440	306	220	160	118	87	63						
				1/12						1297	1007	805	540	380	277	205	154	117	88						
5½″	69	.458	.39	1/8								665	441	306	217	158	114	82	58	39					
				1/10								849	568	398	289	214	160	120	90	47					
				1/12								1031	695	492	361	271	206	158	122	93					
6″	75	.50	.43	1/8								830	555	387	279	205	151	112	82	59	40				
				1/10								1055	711	502	367	275	208	159	121	92	69				
				1/12								1280	869	617	455	345	265	206	161	125	98				
6½″	81	.541	.47	1/8									679	478	347	257	193	145	109	81	58	41			
				1/10									869	617	454	341	261	201	156	121	93	71			
				1/12									1059	757	560	425	329	258	204	161	129	101			
7″	88	.584	.52	1/8									817	577	422	316	238	181	138	105	78	57	39		
				1/10									1042	743	548	414	319	248	195	153	120	93	71		
				1/12									1272	912	677	516	400	317	251	201	162	129	103		
7½″	94	.625	.56	1/8										686	504	379	288	222	172	132	101	76	55	38	
				1/10										881	653	496	384	301	238	189	150	118	93	71	
				1/12										1076	804	615	480	381	304	245	198	161	130	104	
8″	100	.667	.60	1/8										805	592	448	343	266	207	162	126	97	73	53	37
				1/10										1030	765	584	454	358	284	228	182	146	116	92	71
				1/12										1255	937	720	565	450	361	293	239	195	160	129	105
8½″	106	.709	.64	1/8											690	524	404	315	248	195	154	120	93	70	51
				1/10											889	680	530	420	336	271	219	176	142	114	90
				1/12											1088	837	657	526	424	345	283	234	192	158	130
9″	113	.75	.69	1/8											792	603	467	365	289	229	182	145	113	87	66
				1/10											1017	782	611	484	389	315	256	209	169	137	110
				1/12											1243	957	755	605	491	400	330	273	227	187	155
10″	125	.833	.77	1/8												783	609	480	384	309	249	201	161	129	101
				1/10												1005	791	632	511	417	343	282	233	192	157
				1/12												1235	975	785	639	525	435	363	305	255	215
11″	138	.917	.86	1/8												982	767	610	492	397	324	265	216	176	142
				1/10												1260	993	797	647	532	440	365	304	254	212
				1/12												1537	1222	985	804	666	556	466	392	332	282
12″	150	1.00	.95	1/8													945	755	611	498	409	337	278	230	188
				1/10													1219	980	800	660	548	459	385	324	272
				1/12													1490	1210	990	822	689	580	492	418	357

WEIGHT OF SLAB NOT INCLUDED.

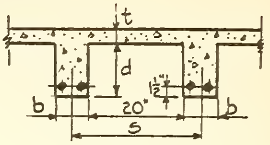
REINFORCED CONCRETE JOIST

UNIVERSAL LOAD TABLES

The load co-efficients and values of A_s given are based on max. moments and are to be used in design for safe load and steel area only. Example: Total load 150#/□′, span 20′-0″, $\frac{WL}{12}$, 2½″ floor slab; required A_s and size of joist. From inspection 6″x10″ or 5″x12″ suitable. For 6″x10″, $A_s = (150 \div 361) \times 1.76 = 0.73□''$ per joist; for 5″x12″, $A_s = (150 \div 463) \times 1.79 = 0.58□''$. 6″x10″ joist requires .40 cu. ft. conc. per sq. ft.; 5″x12″ requires .408 but saves steel. The shear in 5″x12″ joist (most economical) is

$$(150 \div 163) \times 60 = 55\#□''.$$

If increased shear is allowed, for instance 80#/□″, as follows: $(60 \div 80) \times 150 = 112.5\#$ equiv. load; $(112.5 \div 361) \times 1.62 = 0.505□''$ steel with 4″x10″ joist.



$f_s = 18000$
$f_c = 700$
$v = 60$
$n = 15$

20″ Forms

SLAB	DEPTH	WIDTH	SPAC.	LBS. PER SQ. FOOT	CU. FT. VOL. CONC. SQ. FT.	MAX. SHEAR. JOIST AT 60 LBS. SQ. IN.	A_s AREA STEEL			Allowable Loads Per Sq. Ft. in Pounds, For Spans in Feet																				
t	d	b	s				$\frac{WL}{8}$	$\frac{WL}{10}$	$\frac{WL}{12}$	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
2″	6″	LOAD CO-EFFICIENT =								562	465	390	333	287	250	220	194	173	156	140										
		4	24	38	.25	1365	1.62	1.30	1.08	136	124	114	105	98	91	85	80	76	72	68		ALL LOADS INCLUDE WEIGHT OF								
		5	25	40	.267	1705	1.68	1.34	1.12	164	149	136	126	117	109	102	96	91	86	82		JOIST AND SLAB.								
		6	26	42	.282	2050	1.75	1.40	1.17	189	172	158	145	135	126	118	111	105	99	95										
2″	8″	LOAD CO-EFFICIENT =								875	725	608	517	446	389	342	302	270	242	219	198	181								
		4	24	42	.278	1785	1.90	1.52	1.27	178	162	149	137	128	119	112	105	99	94	89	85	81								
		5	25	45	.30	2230	1.98	1.58	1.32	214	195	178	165	153	143	134	126	119	113	107	102	97								
		6	26	48	.32	2680	2.07	1.66	1.38	248	225	206	190	177	165	155	145	137	130	124	118	112								
2″	10″	LOAD CO-EFFICIENT =								1200	990	831	708	610	533	468	415	370	332	300	272	248	227	208						
		4	24	46	.306	2210	2.07	1.66	1.38	221	200	184	170	158	147	138	130	123	116	110	105	100	96	92						
		5	25	50	.333	2750	2.16	1.73	1.44	264	240	220	203	188	176	165	155	146	139	132	126	120	115	110						
		6	26	54	.359	3310	2.25	1.80	1.50	305	278	255	235	218	204	191	180	170	161	153	145	139	133	127						
2″	12″	LOAD CO-EFFICIENT =								1530	1260	1060	902	779	678	596	528	471	423	382	346	317	289	265	244	226				
		5	25	55	.367	3280	2.28	1.83	1.52	314	286	267	242	225	210	197	185	175	166	157	150	143	137	131	126	121				
		6	26	60	.397	3940	2.37	1.90	1.58	363	330	303	280	260	242	227	214	202	191	182	173	165	158	151	145	140				
		7	27	64	.425	4600	2.46	1.97	1.64	409	372	341	314	292	272	256	240	227	215	204	195	186	178	170	163	157				
		8	28	68	.452	5250	2.55	2.04	1.70	450	410	375	347	322	300	282	265	250	237	225	215	205	195	188	180	173				
2½″	6″	LOAD CO-EFFICIENT =								665	550	461	393	339	295	260	230	205	184	166										
		4	24	44	.291	1470	1.80	1.44	1.20	147	133	122	113	105	98	92	86	82	77	73										
		5	25	46	.308	1835	1.83	1.50	1.25	176	160	147	135	126	117	110	103	98	93	88										
		6	26	49	.324	2200	1.95	1.56	1.30	203	184	169	156	145	135	127	120	113	107	102										
2½″	8″	LOAD CO-EFFICIENT =								1046	866	726	619	534	465	410	362	323	290	262	238	216								
		4	24	48	.319	1890	2.19	1.75	1.46	189	172	157	145	135	126	118	111	105	100	95	90	86								
		5	25	51	.342	2360	2.28	1.83	1.52	226	206	189	174	162	151	141	133	126	119	113	108	103								
		6	26	54	.362	2840	2.37	1.90	1.58	262	238	218	202	187	175	164	154	145	138	131	125	119								
2½″	10″	LOAD CO-EFFICIENT =								1444	1192	1001	854	736	642	564	498	445	400	361	328	298	273	251						
		4	24	52	.347	2310	2.43	1.95	1.62	231	210	192	178	165	154	144	136	128	121	115	110	105	100	96						
		5	25	56	.375	2890	2.53	2.03	1.69	277	252	231	214	198	185	174	163	154	146	138	132	126	121	115						
		6	26	60	.400	3470	2.64	2.11	1.76	320	291	267	246	229	213	200	188	178	168	160	152	145	139	133						
2½″	12″	LOAD CO-EFFICIENT =								1850	1530	1284	1094	943	823	723	640	570	512	463	420	382	350	321	296	274				
		5	25	61	.408	3410	2.69	2.15	1.79	327	298	273	252	234	218	205	192	182	172	163	156	149	142	136	131	126				
		6	26	66	.439	4100	2.79	2.23	1.86	378	344	315	291	270	252	236	222	210	199	189	180	172	164	157	151	146				
		7	27	70	.467	4775	2.90	2.32	1.93	425	386	354	326	303	283	265	250	236	223	212	202	193	184	177	170	163				
		8	28	74	.494	5460	3.00	2.40	2.00	469	426	390	360	334	312	293	275	260	247	234	223	213	203	195	187	180				
2½″	14″	LOAD CO-EFFICIENT =								2260	1865	1565	1330	1150	1000	880	780	697	625	564	512	466	427	392	361	334	309	288	268	251
		5	25	69	.462	3940	2.82	2.26	1.88	378	344	315	291	270	252	236	222	210	199	189	180	172	165	158	151	145	140	135	130	126
		6	26	72	.478	4720	2.92	2.34	1.95	435	395	362	335	311	290	272	256	242	229	218	207	198	189	181	174	168	161	155	150	145
		7	27	77	.511	5520	3.03	2.42	2.02	491	446	409	377	350	327	307	289	273	258	245	233	223	213	205	196	189	181	175	169	163
		8	28	81	.542	6300	3.15	2.52	2.10	540	490	450	415	385	360	337	317	300	284	270	257	245	235	225	216	207	200	193	186	180
		9	29	86	.570	7080	3.25	2.60	2.17	586	533	488	450	418	390	366	344	325	309	293	279	266	254	244	234	225	217	209	202	195
3″	10″	LOAD CO-EFFICIENT =								1670	1385	1160	988	854	743	654	578	515	463	418	380	346	316	290						
		4	24	58	.389	2420	2.71	2.17	1.81	242	220	201	186	173	161	151	142	134	127	121	115	110	105	101						
		5	25	63	.416	3020	2.82	2.26	1.88	290	264	241	223	207	193	181	170	161	152	145	138	132	126	120						
		6	26	66	.442	3620	2.94	2.35	1.96	334	304	278	257	239	222	209	196	185	176	167	159	152	145	139						
3″	12″	LOAD CO-EFFICIENT =								2150	1775	1490	1270	1095	955	840	742	663	595	537	488	444	407	373	344	318				
		5	25	68	.45	3540	3.05	2.44	2.03	340	310	283	262	243	227	213	200	189	179	170	162	154	148	142	136	131				
		6	26	72	.48	4250	3.16	2.53	2.11	392	356	327	302	280	262	245	231	218	207	196	187	178	171	163	157	151				
		7	27	77	.51	4960	3.29	2.63	2.19	441	400	367	339	315	294	275	259	245	232	220	210	200	192	184	176	170				
		8	28	80	.535	5660	3.40	2.72	2.27	485	440	405	374	347	324	304	285	270	256	243	231	221	211	202	194	186				
3″	14″	LOAD CO-EFFICIENT =								2640	2180	1830	1555	1343	1170	1030	910	813	730	660	598	545	498	457	422	390	361	336	314	293
		5	25	73	.483	4060	3.22	2.58	2.15	389	354	325	300	278	260	244	229	216	205	195	185	177	170	162	156	150	144	139	135	130
		6	26	78	.52	4880	3.36	2.69	2.24	450	409	375	346	322	300	281	265	250	237	225	214	205	196	188	180	173	167	161	155	150
		7	27	83	.553	5700	3.48	2.78	2.32	506	460	422	390	361	337	316	298	281	266	253	241	230	220	211	203	194	187	181	175	168
		8	28	88	.583	6500	3.60	2.88	2.40	557	506	464	429	398	371	348	328	309	293	278	265	253	242	232	223	214	206	199	192	185
		9	29	92	.611	7320	3.74	2.99	2.49	606	551	505	465	433	404	378	356	336	319	303	288	275	263	252	242	233	224	216	209	202

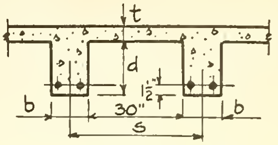
REINFORCED CONCRETE JOIST

UNIVERSAL LOAD TABLES

The load co-efficients and values of A_s given are based on max. moments and are to be used in design for safe load and steel area only. Example: Total load 150 ♯□′, span 20′-0″, $\frac{WL}{12}$, 2½″ floor slab; required A_s and size joist. From inspection 7″x12″ or 6″x14″ suitable. For 7″x12″, $A_s = (150 \div 463) \times 2.65 = 0.86$□″ per joist.
For 6″x14″, $A_s = (150 \div 564) \times 2.70 = 0.72$□″.

Both sizes require .40 cu. ft. conc. per sq. ft; the 6″x14″ requires less steel.

The shear in 6″x14″ joist (most economical) is $(150 \div 157) \times 60 = 57$ ♯/□″. If increased shear is allowed, for instance 80 ♯□″, as follows: $(60 \div 80) \times 150 = 112.5$ ♯ equiv. load; $A_s = (112.5 \div 463) \times 2.51 = 0.61$□″ with joist size 5″x12″, req. .35 cu. ft. conc.



$f_s = 18000$
$f_c = 700$
$v = 60$
$n = 15$

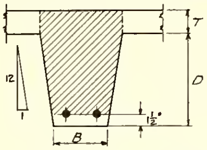
30″ Forms

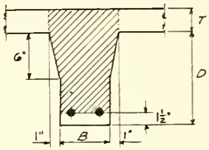
SLAB t	DEPTH d	WIDTH b	SPAC. s	LBS. PER SQ. FOOT	CU. FT. VOL. CONC. SQ. FT.	MAX. SHEAR. JOIST AT 60 LBS. SQ. IN.	A_s AREA STEEL			Allowable Loads Per Sq. Ft. in Pounds, For Spans in Feet																				
							$\frac{WL}{8}$	$\frac{WL}{10}$	$\frac{WL}{12}$	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
2″	6″	LOAD CO-EFFICIENT =								562	465	390	333	287	250	220	194	173	156	140										
		4	34	34	.23	1365	2.29	1.84	1.53	97	88	80	74	69	64	60	57	54	51	48		ALL LOADS INCLUDE WEIGHT OF								
		5	35	36	.24	1705	2.36	1.89	1.57	117	106	97	90	83	78	73	69	65	62	59		JOIST AND SLAB.								
		6	36	38	.25	2050	2.43	1.95	1.62	137	124	114	105	98	91	86	81	76	72	68										
2″	8″	LOAD CO-EFFICIENT =								875	725	608	517	446	389	342	302	270	242	219	198	181								
		4	34	37	.25	1785	2.70	2.16	1.80	126	115	105	97	90	84	79	74	70	66	63	60	57								
		5	35	39	.26	2230	2.77	2.22	1.85	153	139	128	118	110	102	96	90	85	81	77	73	70								
		6	36	42	.28	2680	2.86	2.29	1.90	179	163	149	138	128	119	112	105	99	94	90	85	81								
2″	10″	LOAD CO-EFFICIENT =								1200	990	831	708	610	533	468	415	370	332	300	272	248	227	208						
		4	34	40	.27	2210	2.93	2.35	1.96	156	142	130	120	112	104	98	92	87	82	78	74	71	68	65						
		5	35	43	.29	2750	3.02	2.41	2.01	189	172	157	145	135	126	118	111	105	100	95	90	86	82	79						
		6	36	46	.31	3310	3.10	2.48	2.07	221	201	184	170	158	147	138	130	123	116	110	105	100	96	92						
2″	12″	LOAD CO-EFFICIENT =								1530	1260	1060	902	779	678	596	528	471	423	382	346	317	289	265	244	226				
		5	35	46	.31	3280	3.19	2.55	2.13	225	205	188	173	161	150	140	132	125	119	113	107	102	98	94	90	87				
		6	36	50	.33	3940	3.28	2.63	2.19	263	239	219	202	188	175	164	154	146	138	131	125	120	114	110	105	101				
		7	37	53	.36	4600	3.38	2.70	2.26	298	271	249	230	213	199	187	176	166	157	149	142	136	130	124	119	115				
		8	38	57	.38	5250	3.47	2.77	2.31	332	302	276	255	237	221	207	195	184	174	166	158	151	144	138	133	128				
2½″	6″	LOAD CO-EFFICIENT =								665	550	461	393	339	295	260	230	205	184	166										
		4	34	40	.27	1470	2.55	2.04	1.70	104	95	87	80	74	69	65	61	58	55	52										
		5	35	42	.28	1835	2.62	2.10	1.75	126	114	105	97	90	84	79	74	70	66	63										
		6	36	44	.29	2200	2.70	2.16	1.80	147	133	122	113	105	95	92	86	82	77	73										
2½″	8″	LOAD CO-EFFICIENT =								1046	866	726	619	534	465	410	362	323	290	262	238	216								
		4	34	43	.29	1890	3.10	2.48	2.07	134	121	111	103	95	89	83	78	74	70	67	64	61								
		5	35	46	.30	2360	3.19	2.55	2.13	162	147	135	125	116	108	101	95	90	85	81	77	74								
		6	36	48	.32	2840	3.28	2.63	2.19	189	172	158	146	135	126	118	111	105	100	95	90	86								
2½″	10″	LOAD CO-EFFICIENT =								1444	1192	1001	854	736	642	564	498	445	400	361	328	298	273	251						
		4	34	46	.31	2310	3.44	2.75	2.30	163	148	136	125	116	109	102	96	91	86	82	78	74	71	68						
		5	35	49	.33	2890	3.54	2.83	2.36	198	180	165	153	142	132	124	116	110	104	99	94	90	86	83						
		6	36	52	.35	3470	3.64	2.92	2.43	231	210	193	178	165	154	144	136	128	122	115	110	105	100	96						
2½″	12″	LOAD CO-EFFICIENT =								1850	1530	1284	1094	943	823	723	640	570	512	463	420	382	350	321	296	274				
		5	35	53	.35	3410	3.76	3.01	2.51	234	213	195	180	167	156	146	137	130	123	117	111	106	101	98	94	90				
		6	36	56	.38	4100	3.87	3.10	2.58	273	248	228	210	195	182	171	161	152	144	137	130	124	119	114	109	105				
		7	37	60	.40	4775	3.98	3.18	2.65	310	282	258	238	221	207	194	182	172	163	155	148	141	135	129	124	119				
		8	38	63	.42	5460	4.08	3.26	2.72	345	314	288	266	247	230	216	203	192	182	173	164	157	150	144	138	133				
2½″	14″	LOAD CO-EFFICIENT =								2260	1865	1565	1330	1150	1000	880	780	697	625	564	512	466	427	392	361	334	309	288	268	251
		5	35	56	.38	3940	3.93	3.14	2.62	270	246	225	208	193	180	169	159	150	142	135	129	123	117	113	108	104	100	96	93	90
		6	36	60	.40	4720	4.05	3.24	2.70	314	286	262	242	224	210	196	185	175	166	157	150	143	137	131	126	121	117	112	108	105
		7	37	64	.43	5520	4.17	3.34	2.78	358	326	299	275	256	239	224	211	199	189	179	171	163	156	149	143	138	133	128	124	120
		8	38	68	.45	6300	4.27	3.42	2.85	398	362	331	306	284	265	248	234	221	209	199	190	181	173	166	159	153	147	142	137	133
		9	39	72	.48	7080	4.38	3.51	2.93	436	396	363	335	312	291	272	256	242	229	218	207	198	190	182	174	168	161	156	150	145
3″	10″	LOAD CO-EFFICIENT =								1670	1385	1160	988	854	743	654	578	515	463	418	380	346	316	290						
		4	34	52	.35	2420	3.84	3.07	2.56	171	155	142	131	122	114	107	100	95	90	85	81	78	74	71						
		5	35	55	.37	3020	3.95	3.16	2.64	207	188	172	159	148	138	129	121	115	109	103	99	94	90	86						
		6	36	58	.39	3620	4.06	3.25	2.71	241	219	201	186	172	161	151	142	134	127	121	115	110	105	101						
3″	12″	LOAD CO-EFFICIENT =								2150	1775	1490	1270	1095	955	840	742	663	595	537	488	444	407	373	344	318				
		5	35	59	.39	3540	4.26	3.41	2.84	243	221	202	187	173	162	152	143	135	128	122	116	110	105	101	97	93				
		6	36	63	.42	4250	4.38	3.50	2.92	284	257	236	218	202	189	177	167	158	149	142	135	129	123	118	113	109				
		7	37	66	.44	4960	4.51	3.61	3.01	321	292	268	248	230	214	201	190	178	169	161	153	146	140	134	129	124				
		8	38	69	.45	5660	4.64	3.71	3.09	358	325	298	275	256	239	224	210	199	188	179	171	163	156	149	143	138				
3″	14″	LOAD CO-EFFICIENT =								2640	2180	1830	1555	1343	1170	1030	910	813	730	660	598	545	498	457	422	390	361	336	314	293
		5	35	63	.42	4060	4.50	3.60	3.00	279	253	232	214	199	186	174	164	155	147	139	133	127	121	116	111	107	103	99	96	93
		6	36	67	.44	4880	4.64	3.71	3.09	326	296	271	250	232	217	203	192	181	171	163	155	148	142	136	130	125	120	116	112	108
		7	37	71	.47	5700	4.77	3.82	3.18	369	336	308	284	264	246	231	218	205	194	185	176	168	161	154	148	142	137	132	128	124
		8	38	74	.50	6500	4.89	3.92	3.26	410	373	342	316	294	274	257	242	228	216	205	195	186	177	171	164	158	152	147	142	137
		9	39	78	.52	7320	5.03	4.03	3.35	450	410	376	346	322	300	281	265	250	237	225	214	205	196	188	180	173	167	161	155	150

v = Unit Shear
V = Total Shear
$j = .875$
A = Cross Hatched Area in^2
$K = jA$

SHEAR CONSTANTS
FOR
REINFORCED CONCRETE JOIST
SIMPLE SPANS

$$v = \frac{V}{K}$$

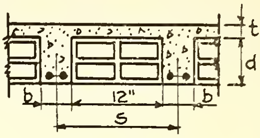




D	B''	Value of K			D	B''	Value of K		
		T					T		
		2	2½	3			2	2½	3
6''	4''	27.0	29.1	31.3	6''	4''	31.5	34.1	36.8
	5''	32.6	35.3	37.9		5''	37.2	40.2	43.3
	6''	38.3	41.4	44.5		6''	42.9	46.4	49.9
	7''	44.0	47.5	51.0		7''	48.6	52.5	56.4
	8''	49.7	53.6	57.6		8''	54.2	58.6	63.0
	9''	55.4	59.8	64.1		9''	59.9	64.8	69.6
	10''	61.1	65.9	70.7		10''	65.6	70.9	76.1
	11''	66.8	72.0	77.3		11''	71.3	77.0	82.7
	12''	72.5	78.1	83.8		12''	77.0	83.1	89.2
8''	4''	36.6	38.9	41.2	8''	4''	38.5	41.1	43.8
	5''	44.0	46.8	49.6		5''	45.9	49.0	52.1
	6''	51.5	54.7	57.9		6''	53.4	56.9	60.4
	7''	58.9	62.5	66.2		7''	60.8	64.8	68.7
	8''	66.3	70.4	74.5		8''	68.2	72.6	77.0
	9''	73.8	78.3	82.8		9''	75.7	80.5	85.3
	10''	81.2	86.2	91.1		10''	83.1	88.4	93.6
	11''	88.6	94.0	99.4		11''	90.6	96.2	101.9
	12''	96.1	101.9	107.8		12''	98.0	104.1	110.2
	13''	103.5	109.8	116.1		13''	105.4	112.0	118.6
	14''	111.0	117.7	124.4		14''	112.9	119.9	126.9
10''	4''	46.8	49.3	51.8	10''	4''	45.5	48.1	50.8
	5''	56.0	58.9	61.8		5''	54.7	57.8	60.8
	6''	65.2	68.5	71.9		6''	63.9	67.4	70.9
	7''	74.3	78.1	81.9		7''	73.1	77.0	80.9
	8''	83.5	87.8	92.0		8''	82.2	86.6	91.0
	9''	92.7	97.4	102.1		9''	91.4	96.2	101.1
	10''	101.9	107.0	112.1		10''	100.6	105.9	111.1
	11''	111.1	116.6	122.2		11''	109.8	115.5	121.2
	12''	120.3	126.3	132.2		12''	119.0	125.1	131.2
	13''	129.5	135.9	142.3		13''	128.2	134.8	141.3
	14''	138.7	145.5	152.4		14''	137.4	144.4	151.4
	15''	147.8	155.1	162.4		15''	146.6	154.0	161.4
	16''	157.0	164.8	172.5		16''	155.8	163.6	171.5
12''	5''	68.5	71.6	74.6	12''	5''	63.4	66.5	69.6
	6''	79.5	83.0	86.5		6''	74.4	77.9	81.4
	7''	90.4	94.3	98.3		7''	85.3	89.2	93.2
	8''	101.3	105.7	110.1		8''	96.2	100.6	105.0
	9''	112.3	117.1	121.9		9''	107.2	112.0	116.8
	10''	123.2	128.5	133.7		10''	118.1	123.4	128.6
	11''	134.1	139.8	145.5		11''	129.1	134.8	140.4
	12''	145.1	151.2	157.3		12''	140.0	146.1	152.2
	13''	156.0	162.6	169.1		13''	150.9	157.5	164.1
	14''	167.0	174.0	181.0		14''	161.9	168.9	175.9
	15''	177.9	185.3	192.8		15''	172.8	180.2	187.7
	16''	188.8	196.7	204.6		16''	183.8	191.6	199.5
14''	5''	81.6	84.8	88.1	14''	5''	72.2	75.2	78.3
	6''	94.3	98.0	101.6		6''	84.9	88.4	91.9
	7''	107.0	111.1	115.2		7''	97.6	101.5	105.4
	8''	119.7	124.2	128.8		8''	110.2	114.6	119.0
	9''	132.4	137.4	142.3		9''	122.9	127.8	132.6
	10''	145.1	150.5	155.9		10''	135.6	140.9	146.1
	11''	157.8	163.6	169.4		11''	148.3	154.0	159.7
	12''	170.5	176.7	183.0		12''	161.0	167.1	173.2
	13''	183.1	189.8	196.6		13''	173.7	180.2	186.8
	14''	195.8	203.0	210.1		14''	186.4	193.4	200.4
	15''	208.5	216.1	223.7		15''	199.1	206.5	213.9
	16''	221.2	229.2	237.2		16''	211.8	219.6	227.5

CLAY TILE AND CONCRETE JOIST

UNIVERSAL LOAD TABLES



The load co-efficients and values of A_s given are based on max. moments and are to be used in design for safe load and steel area only. Example: Total load 150♯□′, span 20′-0″, $\frac{WL}{12}$ 2½″ slab; required A_s and size joist. From inspection 4″x8″ or 4″x9″ suitable

For 4″x8″: $A_s = (150 \div 287) \times 1.00 = 0.523$□″ per joist.
For 4″x9″: $A_s = (150 \div 336) \times 1.05 = 0.47$□″.

The shear in 4″x8″ joist is $(150 \div 150) \times 60 = 60$♯□″.

If increased shear is allowed, for instance 80♯□″, joist and steel would be as follows: $(60 \div 80) \times 150 = 112.5$♯ equiv. load; $A_s = (112.5 \div 190) \times .85 = 0.503$□″ for 4″x6″ joist.

$f_s = 18000$
$f_c = 700$
$v = 60$
$n = 15$

CLAY TILE

SLAB	DEPTH	WIDTH	SPAC.	LBS. PER SQ. FOOT	CU. FT. VOL. CONC. SQ. FT.	MAX. SHEAR. JOIST AT 60 LBS. SQ. IN.	A_s AREA STEEL			Allowable Loads Per Sq. Ft. in Pounds, For Spans in Feet																				
t	d	b	s				WL 8	WL 10	WL 12	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
2″	4″					LOAD CO-EFFICIENT =				340	281	236	201	173																
		4	16	50	.25	1050	.86	.69	.57	157	143	131	121	112	ALL LOADS INCLUDE WEIGHT OF JOIST, TILE AND SLAB.															
		5	17	51	.265	1310	.92	.73	.61	185	168	154	142	132																
2″	5″					LOAD CO-EFFICIENT =				485	401	336	286	247	215	189	168													
		4	16	55	.271	1260	1.02	.82	.68	189	172	157	145	135	126	118	111													
		5	17	57	.289	1575	1.08	.87	.72	222	202	185	171	158	148	139	131													
2″	6″					LOAD CO-EFFICIENT =				640	528	444	377	326	284	250	221	197	177	160										
		4	16	60	.292	1470	1.14	.91	.76	220	200	184	170	158	147	138	130	122	116	110										
		5	17	63	.314	1840	1.21	.97	.81	260	236	216	200	186	173	162	153	144	137	130										
2″	7″					LOAD CO-EFFICIENT =				796	658	553	470	406	354	311	275	245	220	199	181									
		4	16	66	.313	1680	1.24	.99	.83	252	229	210	194	180	168	158	148	140	133	126	120									
		5	17	68	.338	2100	1.32	1.06	.88	296	270	247	228	212	198	185	174	165	156	148	141									
2″	8″					LOAD CO-EFFICIENT =				956	790	664	565	487	425	374	330	295	264	239	217	198								
		4	16	73	.333	1890	1.30	1.04	.87	284	258	236	218	202	189	177	167	157	149	142	135	129								
		5	17	76	.362	2360	1.38	1.10	.92	333	303	278	256	238	222	208	196	185	175	167	158	151								
		6	18	78	.388	2835	1.46	1.17	.98	378	344	315	291	270	252	236	222	210	199	189	180	172								
2″	9″					LOAD CO-EFFICIENT =				1120	925	775	660	570	497	437	386	345	310	280	254	231	212							
		4	16	77	.354	2100	1.36	1.09	.91	315	286	262	242	225	210	197	185	175	166	157	150	143	137							
		5	17	80	.387	2620	1.45	1.16	.97	370	336	308	284	264	246	231	218	205	195	185	176	168	161							
		6	18	83	.417	3150	1.53	1.22	1.02	420	382	350	323	300	280	262	247	233	221	210	200	191	182							
2″	10″					LOAD CO-EFFICIENT =				1280	1060	890	757	651	569	500	442	395	354	320	291	264	242	222						
		4	16	83	.375	2310	1.40	1.12	.93	347	315	289	266	247	231	217	203	192	182	173	165	158	150	144						
		5	17	87	.412	2890	1.49	1.19	.99	408	371	340	314	291	272	255	240	227	215	204	194	186	177	170						
		6	18	90	.445	3460	1.58	1.26	1.05	461	420	384	355	330	308	288	272	256	243	231	220	210	200	192						
2″	12″					LOAD CO-EFFICIENT =				1610	1330	1116	951	820	715	630	556	496	445	402	365	332	304	279	258	238				
		4	16	93	.417	2730	1.46	1.18	.99	410	373	342	315	293	273	256	241	228	216	205	195	187	178	171	164	158				
		5	17	97	.46	3410	1.58	1.26	1.05	482	437	401	370	344	321	301	283	268	254	241	229	219	209	200	193	185				
		6	18	102	.50	4100	1.67	1.33	1.11	546	497	455	420	390	365	341	322	304	288	273	260	249	238	228	219	210				
2″	15″					LOAD CO-EFFICIENT =				2100	1740	1460	1241	1070	935	822	725	648	582	525	477	435	398	365	337	311	288	269	250	233
		4	16	106	.48	3360	1.54	1.23	1.03	504	458	420	388	360	336	315	296	280	265	252	240	229	219	210	202	193	187	180	174	168
		5	17	112	.534	4200	1.64	1.31	1.09	594	539	495	456	424	395	370	349	330	312	297	282	270	258	247	237	228	220	212	204	198
		6	18	118	.573	5040	1.73	1.39	1.16	672	610	560	517	480	448	420	395	373	354	336	320	305	292	280	269	258	248	240	232	224
2½″	4″					LOAD CO-EFFICIENT =				410	339	285	242	210																
		4	16	56	.292	1155	.94	.75	.63	173	157	144	133	124																
		5	17	57	.306	1440	1.00	.80	.67	203	185	170	156	145																
2½″	5″					LOAD CO-EFFICIENT =				574	475	398	339	293	255	224	198													
		4	16	61	.312	1365	1.12	.90	.75	205	186	171	157	146	136	128	120													
		5	17	63	.331	1705	1.19	.95	.79	241	218	200	185	172	160	150	142													
2½″	6″					LOAD CO-EFFICIENT =				760	628	527	448	387	337	297	262	234	210	190										
		4	16	67	.333	1575	1.27	1.02	.85	236	215	197	182	169	157	148	139	131	124	118										
		5	17	69	.356	1970	1.35	1.08	.90	278	252	232	214	198	186	174	164	155	147	139										
2½″	7″					LOAD CO-EFFICIENT				950	785	660	561	485	422	371	328	293	263	237	216									
		4	16	72	.354	1785	1.40	1.12	.93	268	243	223	206	191	179	168	157	149	141	134	127									
		5	17	75	.38	2230	1.49	1.19	.99	315	286	262	242	225	210	197	185	175	166	157	150									
2½″	8″					LOAD CO-EFFICIENT				1146	948	795	677	584	509	448	396	354	317	287	260	237								
		4	16	79	.375	1995	1.50	1.20	1.00	300	272	249	230	214	200	187	176	166	158	150	142	136								
		5	17	82	.404	2490	1.59	1.27	1.06	352	319	293	270	251	234	220	207	196	185	176	167	160								
		6	18	85	.43	2990	1.69	1.35	1.13	399	363	332	307	285	266	249	235	221	210	199	190	181								
2½″	9″					LOAD CO-EFFICIENT				1340	1110	932	793	685	596	525	464	415	372	336	305	277	254							
		4	16	83	.396	2205	1.58	1.26	1.05	331	301	276	255	236	221	207	195	184	174	165	158	150	144							
		5	17	86	.43	2760	1.68	1.34	1.12	390	354	325	300	279	260	243	229	216	205	195	186	177	170							
		6	18	90	.458	3310	1.78	1.42	1.19	441	401	368	340	315	294	276	260	245	232	221	210	201	192							
2½″	10″					LOAD CO-EFFICIENT				1540	1275	1070	910	788	685	604	533	476	427	386	350	319	292	268						
		4	16	89	.416	2415	1.65	1.32	1.10	362	330	302	279	259	241	227	213	201	191	181	172	165	157	151						
		5	17	93	.454	3020	1.76	1.40	1.17	426	387	355	328	305	284	266	250	237	224	213	203	194	185	178						
		6	18	96	.486	3620	1.86	1.48	1.24	483	439	402	372	345	322	302	284	268	254	241	219	210	201	193						
2½″	12″					LOAD CO-EFFICIENT				1950	1610	1352	1151	995	867	763	675	602	540	488	443	404	370	339	313	289				
		4	16	99	.458	2835	1.74	1.39	1.16	425	386	354	327	304	283	266	250	236	224	213	202	193	185	177	170	163				
		5	17	104	.502	3540	1.85	1.48	1.23	500	454	416	385	357	333	312	294	278	263	250	238	227	217	208	200	192				
		6	18	108	.542	4250	1.96	1.57	1.31	566	515	472	436	405	378	354	334	315	298	283	270	257	246	236	227	218				
2½″	15″					LOAD CO-EFFICIENT				2560	2120	1780	1515	1310	1140	1002	885	791	710	640	582	530	485	445	410	379	352	328	305	285
		4	16	112	.52	3460	1.85	1.48	1.23	519	472	432	400	371	346	325	305	288	273	260	247	236	226	216	208	200	192	186	179	173
		5	17	118	.576	4325	1.97	1.57	1.31	610	555	510	470	436	407	381	359	339	322	305	291	278	265	254	244	235	226	218	210	203
		6	18	124	.625	5200	2.08	1.67	1.39	694	630	578	534	495	462	434	408	385	364	347	330	315	301	289	277	267	257	248	239	231

FLAT SLABS

Many types of flat slab design have been used in the past, and city codes and regulations have covered a wide range with regard to moment distribution, slab thickness and the like. But two methods are covered herein: the very excellent recommendations of Taylor, Thompson and Smulski in "Concrete, Plain and Reinforced", and those of the American Concrete Institute, for two-way and four-way design. They will be given in the order noted.

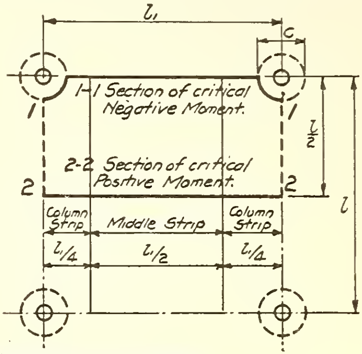
TAYLOR, THOMPSON & SMULSKI.
MOMENTS IN INTERIOR PANELS:

The numerical sum of the positive and negative moments in the direction of either side of square or rectangular panel must not be less than

$$M = 0.09\ Wl\left(1 - \frac{2}{3}\frac{c}{l}\right)^2 \text{ ft. lbs. or}$$

$$1.08\ Wl\left(1 - \frac{2}{3}\frac{c}{l}\right)^2 \text{ inch lbs.}$$

For square panels the moments in each direction are equal; for rectangular panels use the two dimensions of the panel successively for "l".



DISTRIBUTION OF MOMENTS—INTERIOR PANEL.
Two-Way Reinforcing.

Neg. Moment, Col. strips, with drop panel $M_1 = -0.54M$ Without drop panel $M_1 = -0.50M$
Middle strip, with drop panel $M_2 = -0.08M$ Without drop panel $M_2 = -0.10M$
Pos. Moment, Col. strips, with drop panel $M_3 = +0.23M$ Without drop panel $M_3 = +0.24M$
Middle strip, with drop panel $M_4 = +0.15M$ Without drop panel $M_4 = +0.16M$

The positive moment in column strips may be reduced in amount not exceeding $0.02M$, provided the positive moment in middle strip is increased a like amount. Negative moment in column strips may be either increased or decreased an amount not exceeding $0.03M$; if increased, the two positive moments and the middle strip negative moment may be reduced in sum not to exceed the increase, while if it is decreased the other three moments must be increased proportionally, the sum of increase being at least equal to the negative moment reduction.

MOMENTS IN WALL PANELS

The conditions of slab restraint are factors in wall panel design.

CASE 1. Properly designed wall columns with spandrel beams capable of resisting torsion.
CASE 2. Properly designed wall columns, spandrel beams incapable of resisting torsion.
CASE 3. Wall panel supported on brick or masonry bearing walls.

$$M = 0.09\ Wl\left[1 - \frac{1}{3}\left(\frac{c}{l} + \frac{c_1}{l}\right)\right]^2 \text{ ft. lbs. or } 1.08\ Wl\left[1 - \frac{1}{3}\left(\frac{c}{l} + \frac{c_1}{l}\right)\right]^2 \text{ inch lbs.}$$

Where $\frac{c_1}{2}$ = distance from center of column to outside of bracket at wall column. If $\frac{c_1}{2}$ equals $\frac{c}{2}$, values of M in above formula equal values of M for interior panel. Wall columns should have rigidity of at least $\frac{I_c}{h} = 1.5\frac{I}{l}$

DISTRIBUTION OF MOMENTS—WALL PANEL.

CASE 1.	With Drop Panel	Ratio to Int. Pan.	Without Drop	Ratio to Int. Pan.
Negative Moment—1st Interior Column,	$M_1 = 0.62M$	1.15	$M_1 = 0.58M$	1.15
Negative Moment—1st Interior Column,	$M_2 = 0.12M$	1.20	$M_2 = 0.10M$	1.20
Wall Column,	$M_1 = 0.42M$	0.80	$M_1 = 0.40M$	0.80
Wall Column,	$M_2 = 0.08M$	0.80	$M_2 = 0.07M$	0.80
Positive Moment—Column Strips	$M_3 = 0.27M$	1.18	$M_3 = 0.28M$	1.18
Middle strips	$M_4 = 0.18M$	1.20	$M_4 = 0.19M$	1.20
CASE 2.				
Negative Moment—1st Interior Column,	$M_1 = 0.62M$	1.15	$M_1 = 0.58M$	1.15
Negative Moment—1st Interior Column,	$M_2 = 0.13M$	1.25	$M_2 = 0.10M$	1.25
Wall Column,	$M_1 = 0.42M$	0.80	$M_1 = 0.40M$	0.80
Wall Column,	$M_2 = 0.08M$	0.80	$M_2 = 0.07M$	0.80
Positive Moment—Column Strips	$M_3 = 0.27M$	1.18	$M_3 = 0.28M$	1.18
Middle strips	$M_4 = 0.20M$	1.30	$M_4 = 0.21M$	1.30
CASE 3.				
Negative Moment—1st Interior Column,	$M_1 = 0.75M$	1.40	$M_1 = 0.70M$	1.40
Negative Moment—1st Interior Column,	$M_2 = 0.11M$	1.40	$M_2 = 0.14M$	1.40
Wall Column,	$M_1 = 0.20M$	...	$M_1 = 0.20M$	...
Wall Column,	$M_2 = 0.08M$	...	$M_2 = 0.08M$	...
Positive Moment—Column Strips	$M_3 = 0.32M$	1.40	$M_3 = 0.34M$	1.40
Middle strips	$M_4 = 0.21M$	1.40	$M_4 = 0.22M$	1.40

The variations in bending moment for wall panels are as described for interior panels. In Case I. for Wall Panels, spandrel beam must be able to resist torsional moment = ½M_2 at wall.

SLAB THICKNESS, DETERMINED BY NEGATIVE MOMENT.

Without Drop

1. Interior Panel $t_1 = \frac{0.51}{\sqrt{f_c j k}}\, l \left(1 - \frac{2}{3}\frac{c}{l}\right)^2 \sqrt{w} + 1.5$

2. Exterior Panel $t_1 = \frac{0.56}{\sqrt{f_c j k}}\, l \left(1 - \frac{2}{3}\frac{c}{l}\right)^2 \sqrt{w} + 1.5$ Slab restrained.

3. Exterior Panel $t_1 = \frac{0.61}{\sqrt{f_c j k}}\, l \left(1 - \frac{2}{3}\frac{c}{l}\right)^2 \sqrt{w} + 1.5$ Slab freely supported.

With Drop (includes drop)

4. Interior Panel $t_1 = \frac{0.38}{\sqrt{f_c j k}}\, l \left(1 - \frac{2}{3}\frac{c}{l}\right)^2 \sqrt{w\,\frac{l_1}{b}} + 1.5$

5. Exterior Panel $t_1 = \frac{0.41}{\sqrt{f_c j k}}\, l \left(1 - \frac{2}{3}\frac{c}{l}\right)^2 \sqrt{w\,\frac{l_1}{b}} + 1.5$ Slab restrained.

6. Exterior Panel $t_1 = \frac{0.45}{\sqrt{f_c j k}}\, l \left(1 - \frac{2}{3}\frac{c}{l}\right)^2 \sqrt{w\,\frac{l_1}{b}} + 1.5$ Slab freely supported.

SLAB THICKNESS, DETERMINED BY POSITIVE MOMENT.

7. Interior Panel $t_2 = \frac{0.36}{\sqrt{f_c j k}} \left(1 - \frac{2}{3}\frac{c}{l}\right) l \sqrt{w} + 1$

8. Exterior Panel $t_2 = \frac{0.40}{\sqrt{f_c j k}} \left(1 - \frac{2}{3}\frac{c}{l}\right) l \sqrt{w} + 1$ Slab restrained.

9. Exterior Panel $t_2 = \frac{0.43}{\sqrt{f_c j k}} \left(1 - \frac{2}{3}\frac{c}{l}\right) l \sqrt{w} + 1$ Slab freely supported.

With "l" in feet and "w" in lbs. sq. ft., thickness "t" is in inches.

Column Capitals:

Column capitals, or heads, should form an angle of not less than 45° with the horizontal.

For factory and warehouse buildings the head diameter should be 0.225l to 0.25l, where "l" is the span in square panels and the average span in rectangular panels. In buildings carrying light loads the head may be greatly reduced in size, or even omitted.

The diameter to be used in calculations is where the vertical thickness of the head is at least 1½ inches. Round heads are used as basis for design; if square are used, consider head with diameter 20 per cent larger than the side of the square.

Drop Panels:

The width of drop panel is influenced by compressive stresses at points of maximum moment, the diagonal tension stresses at drop edge, and by compression and tension stresses at the edge of the drop. Where design conditions permit, use the following:

Ratio of $\frac{t_3}{d}$ = 0.10,	drop panel width = 0.28 l
0.20	0.30 l
0.40	0.33 l
0.60	0.36 l
0.75	0.38 l

where d = eff. depth slab outside drop panel.
t_3 = depth of drop below slab.
l = span, ct. to ct. of columns.

If drop panels are used at wall columns, width parallel to wall, and thickness, should be same as for interior drops. Width at right angles to wall should be one-half that of corresponding interior drop.

Depth of drop panel shall be computed from largest bending moment; ordinarily that at first interior column. Depths at all other columns should be the same, if possible.

Minimum Slab Thickness

For flat slabs carrying a live load of 100 lbs. sq. ft. or less, the minimum thickness should be $\frac{1}{40}$ of the end span or $\frac{1}{45}$ of the interior span, for slabs without drops. For flat slabs without drops carrying live loads of more than 100 lbs. sq. ft., the minimum thickness should be $\frac{1}{32}$ of the end span or $\frac{1}{36}$ of the interior span. Where drop panels are used, the minimum thickness given may be reduced by ⅛ of the thickness of the drop.

When end spans are not monolithic with columns, as when bearing on brick or masonry walls, the minimum thickness as above found should be increased by 25 per cent.

POINTS OF INFLECTION.

Point of inflection for negative moment is $0.20l_2$ from edge of column head; for positive moment it is $0.18l_2$ from column head. "l_2" is distance between edges of heads.

REINFORCING, FOR COMPRESSION AT HEAD.

Compression stresses, considering drop only:

$$f_c = \frac{0.25\left(1 - 1.2\frac{c}{l}\right)M_1}{jkbd_1^2}$$

Compression stresses, considering both slab and drop:

$$f_c = \frac{0.25\left(1 - 1.2\frac{c}{l}\right)M_1}{\left[\frac{b}{l_1} + \left(\frac{1}{2} - \frac{b}{l_1}\right)\left(\frac{d}{d_1}\right)^2\left(2.5\frac{d}{d_1} - 1.5\right)\right]jkl_1d_1^2}$$

Compression stresses, slab without drop panel:

$$f_c = \frac{0.125\left(1 - 1.2\frac{c}{l}\right)M_1}{jkl_1d^2}$$

The bending moment resisted by the compression steel:

$$M_s = A'_s(n-1)f_c\frac{k-a}{k}d(1-a) \quad = M_1 - M_c$$

The moment of resistance of slab:

$$M_c = \frac{\left[\frac{b}{l_1} + \left(\frac{1}{2} - \frac{b}{l_1}\right)\left(\frac{d}{d_1}\right)^2\left(2.5\frac{d}{d_1} - 1.5\right)\right]}{\dfrac{0.25\left(1 - 1.2\frac{c}{l}\right)}{jk}}\, l_1d_1^2f_c$$

Where M_1 = Neg. moment in col. strips.
M_c = Mom. resisted by concrete.
M_s = Mom. resisted by comp. steel.
l = Span, c. to c. cols. in direction of M_1.
l_1 = Span, c. to c. cols. of right angles to l.
b = Width of drop at right angles to span.
d = Eff. depth of slab,
d_1 = Eff. depth of slab and drop.
A'_s = Area compression steel.
a = Ratio, depth compression steel to depth of slab.

Area of compression steel:

$$A'_s = \frac{M_s}{(n-1)f_c d(1-a)}\;\frac{k}{k-a}$$

Compression stress due to either positive or negative moment in middle strip:

$$f_c = \frac{0.5\,M_n}{jkl_1d^2}$$ where M_n = Moment at section considered.

SHEAR.

The formulae following may be used for either square or rectangular panels:

At col. head,

$$v = \frac{\frac{l_1}{l} - 0.785\left[\dfrac{c + \frac{2(t_1 - 1\frac{1}{2}'')}{12}}{l}\right]^2}{3.14\left[\dfrac{c + \frac{2(t_1 - 1\frac{1}{2}'')}{12}}{l}\right]12}$$

At drop panel,

$$v = \frac{\frac{l_1}{l} - \left[\dfrac{b + \frac{2(t - 1'')}{12}}{l}\right]^2}{4\left[\dfrac{b + \frac{2(t - 1'')}{12}}{l}\right]12}\;\frac{1}{\frac{7}{8}d}wl$$

Where t_1 = Thickness of slab and drop.
t = Thickness of slab.
b = Side of square drop or long side of rectangular drop.
b_1 = Short side rectangular drop.
w = Live and dead load per sq. ft.

Critical section for shear is at $t_1 - 1\frac{1}{2}''$ from col. head for drop, and $t - 1''$ from edge of drop for slab.

BOND.

Bond stresses should be kept within design limits. The formula for bond

$$u = \frac{V}{\Sigma_0 jd}$$

where W = Total dead and live load on panel.
V = $0.35W$ for interior panel; = $0.40W$ for wall panel.

STEEL AREA.

The required area of steel for the various moments

$$A_s = \frac{M}{jdf_s}$$

BEAMS.

Both wall beams for exterior panels, and interior beams around openings should be designed to carry the loads directly coming upon them, plus 20% of the flat slab load from the panel.

COLUMNS.

Flat slab construction is peculiarly liable to induce severe bending stresses in the columns, particularly when panels are not loaded uniformly. For this reason the columns should be investigated for bending and direct stress.

AMERICAN CONCRETE INSTITUTE.

The basic moment formula for interior panels, sum of negative and positive moments, is as before given.

The assumed distribution of moments for fully continuous Interior panels:

2-Way Reinforced Slabs.

Neg. Mom. Col. strips, With drop panel, $M_1 = -0.50M$ Without drop panel, $M_1 = -0.46M$
Middle strip, With drop panel, $M_2 = -0.15M$ Without drop panel, $M_2 = -0.16M$
Pos. Mom. Col. strips, With drop panel, $M_3 = +0.20M$ Without drop panel, $M_3 = +0.22M$
Middle strip, With drop panel, $M_4 = +0.15M$ Without drop panel, $M_4 = +0.16M$

4-Way Reinforced Slabs.

Neg. Mom. Col. strips, With drop panel, $M_1 = -0.54M$ Without drop panel, $M_1 = -0.50M$
Middle strip, With drop panel, $M_2 = -0.08M$ Without drop panel, $M_2 = -0.10M$
Pos. Mom. Col. strips, With drop panel, $M_3 = +0.19M$ Without drop panel, $M_3 = +0.20M$
Middle strip, With drop panel, $M_4 = +0.19M$ Without drop panel, $M_4 = +0.20M$

The width of the direct bands in the 4-way system shall be approximately 0.4 of the panel width at right angles to the direction of the band, and for the diagonal bands approximately 0.4 of the average span length. The reinforcement in the direct bands shall be assumed to resist the entire positive moment for the column strip, and the two diagonal bands resist the entire positive moment of the middle strip. Reinforcement for negative moment for column strips shall include the area of reinforcement for negative moment in diagonal bands, multiplied by the cosine of the angle between direct and diagonal bands, plus the full area of reinforcing required for negative moment in the direct band. Negative reinforcing for the middle strip shall be provided independently of the diagonal bands.

For 4-way slab with drop panel the following table of co-efficients may be used in determining the reinforcing required in each band:

Direct band,	at center	amount $= +0.012Wl$
Diagonal band,	at center	$= +0.009Wl$
Direct band,	at column head	$= -0.020Wl$
Diagonal band,	at column head	$= -0.011Wl$
Top band, across direct band,	between columns	$= -0.005Wl$

Where "l" is the center to center distance between columns for direct bands, and the average value of "l" for the direct bands when computing diagonal band. Moments are on sections at right angles to direction of bands.

THICKNESS OF SLABS AND DROPS.

For slabs without drops, using 2000 lb. concrete:

$$t_1 = 0.038 \left(1 - 1.44\frac{c}{l}\right) l \sqrt{w} + 1\tfrac{1}{2}$$

For slabs with drops, using 2000 lb. concrete; the slab thickness beyond drop:

$$t_2 = 0.02l \sqrt{w} + 1$$

The depth of drop shall be not more than $1.5t_2$, nor less than $1.25t_2$. The side or diameter of the drop shall not be less than 0.35 the panel width in the parallel direction.

For 2000 lb. concrete the slab thickness shall in no case be less than $l/_{32}$ for floor slabs, nor $l/_{40}$ for roof slabs. In the formulae above, "l" is the panel length, center to center of columns, long way of panel.

When concrete of higher strength than 2000 lb. is used, the thickness given by formulae above, and the limiting thickness, may be reduced by multiplying by the factor

$$\sqrt[3]{\frac{2000}{f'_c}}$$

WALL PANELS.

In wall panels and other panels in which the slab is not continuous on one edge, the maximum positive moments on principal design sections parallel to discontinuous edge shall be increased by 25 per cent.

At the wall or discontinuous edge the negative moment in column strips shall be taken as not less than 90 per cent and in the middle strip not less than 62½ per cent of corresponding moments for interior panel.

Where there is a beam or bearing wall at column center of an interior panel, negative moment in middle strip at this point, perpendicular to beam or wall shall be increased 30 per cent. The half column strip parallel to and on each side of the beam or wall shall be designed to resist at least 25% of the ordinary moment for column strip, interior panel.

GENERAL.

The data herein relate only to designs three or more panels in width, and for panels in which the ratio of length to width does not exceed 1.33. For structures of less than three panels width, or for irregular panels, an analysis of moments in slabs and columns must be made.

REINFORCING.

The ratio of reinforcement for negative moment in column strips shall not exceed the value of "*p*" for balanced reinforcement, except where compression steel is used.

The ratio of reinforcement in any strip shall not be less than 0.0025. Bars shall not be spaced farther apart than one and one-half times the slab thickness.

All bars must be securely fastened in their proper place. The full area of steel required for negative moment at the column head shall be continued in the same plane close to the upper surface of the slab to the edge of the drop panel, but in no case less than a distance of 0.20*l* from column center line. Lapped splices should not be permitted at or near regions of maximum stress.

For column strips, at least 0.4 of the steel area required at the section for positive moment in the column strip shall be of such length and so placed as to reinforce the negative moment section at the two adjacent column heads. These and all other negative moment bars shall extend into the adjacent panel at least 0.05*l* beyond the inflection point. Not less than one-third of the bars used for positive reinforcing in the column strip shall extend into the drop panel at least twenty bar diameters and in no case less than 12 inches. In case no drop panel is used they shall extend to within 0.125*l* of the center line of the columns or supports. The balance of the positive column strip bars shall extend at least 0.33*l* on either side of the panel center line.

In 2-way systems at least half of the middle strip positive bars shall be bent up and extend over the main bands at both sides of the panel to a point at least 0.25*l* beyond column center lines. The location of the bends shall be such that for a distance of 0.15*l* for slabs with drop panels, or 0.125*l* for slabs without drop panels, on each side of the column center lines, the full reinforcement required for negative moment will be provided in the top face of the slab. The full reinforcement for positive moment in the middle strip shall extend in the bottom face of the slab to a point at least 0.30*l* on either side of the panel center line, and at least 50 per cent shall extend to points 0.325*l* on either side of the panel center line for slabs with drop panels, or 0.35*l* for slabs without drop panels.

In 4-way systems, for diagonal bands, at least 0.4 of the steel area required at the section for positive moment shall be of such length and so placed as to reinforce the negative moment section at the two diagonally opposite column heads. These and all other bars for negative reinforcing shall extend into the adjoining panel to points at least 0.40*l* beyond a line drawn through the column center perpendicular to the direction of the band. The straight bars for positive moment in the diagonal bands shall not be shorter than the longer straight bars of the direct bands. The middle strip negative bars shall extend not less than 0.25*l* on either side of the column center line.

Positive moment reinforcing, in a wall panel, perpendicular to the discontinuous edge, shall extend to this edge and have embedment of at least 6 inches in spandrel beam or column. All negative bars shall be bent or hooked at spandrel beams or columns for adequate bond.

OPENINGS IN FLAT SLABS.

Openings of any size may be cut through the floor in the area common to two intersecting middle strips, provided the total positive and negative moments be maintained and are properly redistributed between the remaining principal design sections to meet the new conditions.

In any area common to two column strips, not more than one opening shall be allowed, and the greatest dimension of such an opening shall not exceed $\frac{1}{20}l$.

In any area common to one column strip and one middle strip, openings shall not interrupt more than one-fourth of the bars in either strip, and the equivalent of the bars so interrupted shall be provided by extra steel on both sides of the opening.

Any opening larger than described above shall be completely framed on all sides with beams to carry the loads to the columns.

COLUMN BRACKETS.

Where wall columns have monolithic brackets instead of capitals, the brackets making an angle of not more than 45° between their faces and the column face, the value of "*c*" in the direction of the bracket may be taken as twice the distance from the center of the column to a point where the structural portion of the bracket is 1½-in. thick, and averaged with the value of "*c*" for an interior column capital in the computations for moment.

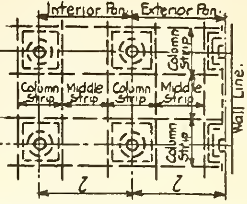
Bands shown for Exterior Panels are those perpendicular to wall. For bands in opposite direction use those for Interior Panel. For Corner Panel use each way as shown for Exterior Panel.

SQUARE FLAT SLAB PANELS

A. C. I. SPECIFICATIONS

$f_c = 800$ $f_s = 20000$ $n = 15$

ALL BARS ROUND DEFORMED



100 LBS. SQ. FT. LIVE LOAD

SIDE SQUARE PANEL	CAPITAL DIAM.	SIDE SQ. DROP PANEL	TOTAL DROP DEPTH	SLAB DEPTH	INTERIOR PANEL					EXTERIOR PANEL					STEEL		CU. FT. CONC. Per □′
					MIDDLE BAND		COLUMN BAND		TOP BARS	MIDDLE BAND		COLUMN BAND		TOP BARS	LBS. SQ. FOOT		
					STR.	BENT	STR.	BENT	STR.	STR.	BENT	STR.	BENT	STR.	INT.	EXT.	
16′	3-9	5-9	9	6	6-⅜	5-⅜	5-⅜	9-⅜	2-⅜	6-⅜	7-⅜	6-⅜	11-⅜	7-⅜	1.40	1.55	.53
17′	4-0	6-0	10	6½	6-⅜	6-⅜	5-⅜	10-⅜	3-⅜	7-⅜	7-⅜	6-⅜	13-⅜	8-⅜	1.50	1.65	.56
18′	4-3	6-6	10½	7	7-⅜	7-⅜	6-⅜	11-⅜	3-⅜	8-⅜	8-⅜	7-⅜	14-⅜	9-⅜	1.60	1.75	.60
19′	4-6	6-9	11	7½	8-⅜	8-⅜	7-⅜	13-⅜	3-⅜	9-⅜	10-⅜	8-⅜	16-⅜	10-⅜	1.72	1.85	.63
20′	4-6	7-0	11	7½	5-½	5-½	4-½	8-½	3-⅜	5-½	6-½	5-½	10-½	6-½	1.77	1.95	.66
21′	4-9	7-6	12	8	5-½	6-½	5-½	9-½	4-⅜	6-½	7-½	6-½	11-½	7-½	1.90	2.10	.69
22′	5-0	7-9	13	8½	6-½	6-½	5-½	10-½	4-⅜	7-½	7-½	6-½	13-½	8-½	2.00	2.20	.72
23′	5-3	8-0	13½	9	6-½	7-½	5-½	11-½	5-⅜	8-½	8-½	7-½	14-½	9-½	2.13	2.32	.76
24′	5-6	8-6	13½	9	8-½	7-½	6-½	12-½	5-⅜	8-½	9-½	8-½	15-½	9-½	2.25	2.45	.79

150 LBS. SQ. FT. LIVE LOAD

SIDE SQUARE PANEL	CAPITAL DIAM.	SIDE SQ. DROP PANEL	TOTAL DROP DEPTH	SLAB DEPTH	INTERIOR PANEL					EXTERIOR PANEL					STEEL		CU. FT. CONC. Per □′
					MIDDLE BAND		COLUMN BAND		TOP BARS	MIDDLE BAND		COLUMN BAND		TOP BARS	LBS. SQ. FOOT		
					STR.	BENT	STR.	BENT	STR.	STR.	BENT	STR.	BENT	STR.	INT.	EXT.	
16′	3-9	5-9	9	6	7-⅜	7-⅜	6-⅜	11-⅜	3-⅜	8-⅜	8-⅜	7-⅜	14-⅜	9-⅜	1.80	1.95	.53
17′	4-0	6-0	10	6½	8-⅜	8-⅜	6-⅜	13-⅜	3-⅜	9-⅜	9-⅜	8-⅜	16-⅜	10-⅜	1.90	2.10	.56
18′	4-3	6-6	10½	7	9-⅜	8-⅜	7-⅜	14-⅜	4-⅜	10-⅜	10-⅜	9-⅜	18-⅜	11-⅜	2.00	2.20	.60
19′	4-6	6-9	11	7½	6-½	5-½	5-½	9-½	4-⅜	6-½	7-½	6-½	11-½	7-½	2.13	2.35	.63
20′	4-6	7-0	11	7½	6-½	6-½	5-½	10-½	4-⅜	7-½	8-½	6-½	13-½	8-½	2.25	2.50	.66
21′	4-9	7-6	12	8	7-½	7-½	6-½	11-½	5-⅜	8-½	8-½	7-½	14-½	9-½	2.38	2.60	.69
22′	5-0	7-9	13	8½	8-½	7-½	6-½	12-½	5-⅜	9-½	9-½	8-½	15-½	9-½	2.50	2.75	.72
23′	5-3	8-0	13½	9	9-½	8-½	7-½	14-½	6-⅜	9-½	10-½	9-½	17-½	10-½	2.65	2.90	.76
24′	5-6	8-6	13½	9	6-⅝	6-⅝	5-⅝	10-⅝	6-⅜	7-⅝	7-⅝	6-⅝	12-⅝	8-⅝	2.80	3.10	.79

200 LBS. SQ. FT. LIVE LOAD

SIDE SQUARE PANEL	CAPITAL DIAM.	SIDE SQ. DROP PANEL	TOTAL DROP DEPTH	SLAB DEPTH	INTERIOR PANEL					EXTERIOR PANEL					STEEL		CU. FT. CONC. Per □′
					MIDDLE BAND		COLUMN BAND		TOP BARS	MIDDLE BAND		COLUMN BAND		TOP BARS	LBS. SQ. FOOT		
					STR.	BENT	STR.	BENT	STR.	STR.	BENT	STR.	BENT	STR.	INT.	EXT.	
16′	3-9	5-9	10	6½	8-⅜	8-⅜	6-⅜	13-⅜	3-⅜	9-⅜	9-⅜	8-⅜	16-⅜	10-⅜	2.10	2.25	.57
17′	4-0	6-0	10½	7	9-⅜	9-⅜	8-⅜	14-⅜	4-⅜	10-⅜	11-⅜	9-⅜	18-⅜	11-⅜	2.20	2.40	.60
18′	4-3	6-6	11	7½	5-½	6-½	5-½	9-½	4-⅜	6-½	7-½	6-½	12-½	7-½	2.32	2.55	.64
19′	4-6	6-9	11	7½	7-½	6-½	5-½	11-½	4-⅜	7-½	8-½	7-½	13-½	8-½	2.45	2.75	.67
20′	4-6	7-0	12	8	7-½	7-½	6-½	12-½	5-⅜	8-½	9-½	7-½	15-½	9-½	2.60	2.90	.71
21′	4-9	7-6	13	8½	8-½	8-½	6-½	13-½	5-⅜	9-½	10-½	8-½	16-½	10-½	2.75	3.05	.74
22′	5-0	7-9	13½	9	6-⅝	5-⅝	5-⅝	9-⅝	6-⅜	6-⅝	7-⅝	5-⅝	12-⅝	7-⅝	2.90	3.20	.78
23′	5-3	8-0	14	9½	6-⅝	6-⅝	5-⅝	10-⅝	7-⅜	7-⅝	7-⅝	6-⅝	13-⅝	8-⅝	3.05	3.35	.81
24′	5-6	8-6	15	10	7-⅝	6-⅝	6-⅝	11-⅝	7-⅜	7-⅝	8-⅝	7-⅝	14-⅝	9-⅝	3.20	3.50	.85

250 LBS. SQ. FT. LIVE LOAD

SIDE SQUARE PANEL	CAPITAL DIAM.	SIDE SQ. DROP PANEL	TOTAL DROP DEPTH	SLAB DEPTH	INTERIOR PANEL					EXTERIOR PANEL					STEEL		CU. FT. CONC. Per □′
					MIDDLE BAND		COLUMN BAND		TOP BARS	MIDDLE BAND		COLUMN BAND		TOP BARS	LBS. SQ. FOOT		
					STR.	BENT	STR.	BENT	STR.	STR.	BENT	STR.	BENT	STR.	INT.	EXT.	
16′	3-9	5-9	10½	7	5-½	5-½	4-½	8-½	3-⅜	5-½	6-½	5-½	10-½	6-½	2.25	2.45	.61
17′	4-0	6-0	11	7½	6-½	5-½	4-½	9-½	4-⅜	6-½	7-½	6-½	11-½	7-½	2.35	2.60	.65
18′	4-3	6-6	12	8	6-½	6-½	5-½	10-½	4-⅜	7-½	7-½	6-½	13-½	8-½	2.50	2.75	.69
19′	4-6	6-9	13	8½	7-½	7-½	6-½	11-½	5-⅜	8-½	8-½	7-½	14-½	9-½	2.65	2.90	.72
20′	4-6	7-0	13½	9	8-½	7-½	7-½	12-½	5-⅜	9-½	9-½	8-½	16-½	10-½	2.80	3.10	.76
21′	4-9	7-6	13½	9	9-½	8-½	7-½	14-½	6-⅜	10-½	10-½	9-½	17-½	11-½	3.00	3.25	.80
22′	5-0	7-9	14	9½	6-⅝	6-⅝	5-⅝	10-⅝	6-⅜	7-⅝	7-⅝	6-⅝	12-⅝	8-⅝	3.15	3.40	.84
23′	5-3	8-0	15	10	7-⅝	6-⅝	5-⅝	11-⅝	7-⅜	7-⅝	8-⅝	6-⅝	14-⅝	8-⅝	3.30	3.60	.87
24′	5-6	8-6	16	10½	8-⅝	7-⅝	6-⅝	12-⅝	8-⅜	8-⅝	8-⅝	7-⅝	15-⅝	9-⅝	3.50	3.75	.91

300 LBS. SQ. FT. LIVE LOAD

SIDE SQUARE PANEL	CAPITAL DIAM.	SIDE SQ. DROP PANEL	TOTAL DROP DEPTH	SLAB DEPTH	INTERIOR PANEL					EXTERIOR PANEL					STEEL		CU. FT. CONC. Per □′
					MIDDLE BAND		COLUMN BAND		TOP BARS	MIDDLE BAND		COLUMN BAND		TOP BARS	LBS. SQ. FOOT		
					STR.	BENT	STR.	BENT	STR.	STR.	BENT	STR.	BENT	STR.	INT.	EXT.	
16′	3-9	5-9	11	7½	6-½	5-½	4-½	9-½	4-⅜	6-½	6-½	5-½	11-½	7-½	2.40	2.65	.65
17′	4-0	6-0	12	8	6-½	6-½	5-½	10-½	4-⅜	7-½	7-½	6-½	12-½	8-½	2.55	2.85	.69
18′	4-3	6-6	13	8½	7-½	6-½	5-½	11-½	5-⅜	8-½	8-½	6-½	14-½	8-½	2.75	3.00	.73
19′	4-6	6-9	13½	9	8-½	7-½	6-½	12-½	5-⅜	8-½	9-½	8-½	15-½	9-½	2.90	3.15	.77
20′	4-6	7-0	14	9½	9-½	8-½	7-½	13-½	6-⅜	10-½	10-½	9-½	17-½	10-½	3.05	3.35	.81
21′	4-9	7-6	15	10	6-⅝	6-⅝	5-⅝	10-⅝	6-⅜	7-⅝	7-⅝	6-⅝	12-⅝	8-⅝	3.20	3.50	.85
22′	5-0	7-9	16	10½	7-⅝	6-⅝	5-⅝	11-⅝	7-⅜	7-⅝	8-⅝	7-⅝	13-⅝	8-⅝	3.35	3.70	.89
23′	5-3	8-0	16	10½	7-⅝	7-⅝	6-⅝	12-⅝	7-⅜	8-⅝	9-⅝	7-⅝	15-⅝	9-⅝	3.55	3.90	.93
24′	5-6	8-6	16½	11	8-⅝	8-⅝	7-⅝	12-⅝	8-⅜	9-⅝	9-⅝	8-⅝	16-⅝	10-⅝	3.70	4.05	.97

BENDING AND DIRECT STRESS

Members subjected to simultaneous bending and direct stress are often encountered, especially in connection with rigid frame design, where both columns and beams are affected. Where many such problems are encountered a standard work on the subject should be used. For the occasional case, the formulae and curves given here will prove of value.

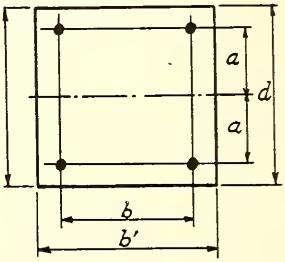
A beam carrying a normal load producing bending, and at the same time being subjected to a direct thrust, is analogous to a column bearing a central load and an eccentric load, or a central load and bending induced from a rigid joint. Thus, a bending moment, "M", and a central load, "N", may be replaced by an eccentric load, "N", acting at "e" distance from the section gravity axis, where $e = \frac{M}{N}$. The load "N" may be either a positive or negative thrust, producing compression or tension respectively.

In the formula and discussion, standard nomenclature is used, with the following additions:

N = Central or eccentric load or thrust.
R = Inclined thrust, whose normal component is N.
a = Distance from gravity axis to c. l of steel.
e = Eccentricity; distance from gravity axis to application of eccentric load.
e_0 = Value of eccentricity producing zero stress in concrete at outer edge.
f_c = Maximum unit compressive stress in concrete.
f_s = Maximum unit tensile stress in steel.
f'_s = Maximum unit compressive stress in steel.
A = Total area of concrete.
A'_s = Total area of steel in tension.
A'_{sc} = Total area of steel in compression.
A_s = Total area of all steel.
y = Perpendicular distance from gravity axis to any fiber.

CASE 1—Rectangular Section: Symmetrical Reinforcing.

COMPRESSION ON SECTION. Based on net area of section, disregarding fireproofing.



Maximum compression in concrete:

$$f_c = \frac{N}{bd}\left[\frac{1}{1+(n-1)\,p} + \frac{6de}{d^2+12\,(n-1)\,pa^2}\right] \qquad e = \frac{M}{N}$$

Stress at any point, "y", from gravity axis:

$$f_c = \frac{N}{bd}\left[\frac{1}{1+(n-1)\,p} \pm \frac{12ye}{d^2+12\,(n-1)\,pa^2}\right]$$

$$f'_s = n\frac{N}{bd}\left[\frac{1}{1+(n-1)\,p} + \frac{12ae}{d^2+12\,(n-1)\,pa^2}\right] = nf_c \text{ at distance "}a\text{" from gravity axis.}$$

If concrete stress is within limits, steel stress is always satisfactory.

Example:

Load $N = 200{,}000$; Bending Moment $M = 400{,}000$"#s; $n = 15$; Col. size 24x24 gross or 20x20" net. $A = 400$□"; $A_s = 4 - 1$□ bars $= 4.0$□"; $p = 4.0 \div 400 = 0.01$; $a = d \div 2 = 10''$; $e = \frac{M}{N} = 2''$.

$$f_c = \frac{200000}{20 \times 20}\left[\frac{1}{1+(15-1)\,.01} + \frac{6 \times 20 \times 2}{20^2+12\,(15-1)\,.01 \times 10^2}\right] = 650\ \#/\square''$$

By using the curves for Case 1, compression on section, the labor of computation is reduced. For above problem, with symmetrical reinforcing, "a" $= \frac{10}{20} = 0.5$. Ratio $\frac{e}{d} = \frac{2}{20} = 0.10$.

Entering curve, for ratios given, $K_1 = 1.3$, being the value of K_1 opposite the intersection of 0.10 (value of $\frac{e}{d}$) and 0.01 (value of p).

The maximum compression is $f_c = K_1\frac{N}{bd} = 1.3 \times \frac{200000}{20 \times 20} = 650\ \#/\square''$

When the reinforcing is not symmetrical the gravity axis will not, of course, be as shown in the example. This axis may be found after determination of the moment of inertia of the section, the value of "a" being the distance from the gravity axis to the center line of the largest group of bars. By using the proper ratio of $\frac{a}{d}$ for the new value, the corresponding curve for Case 1 may be used.

It is not good practice to utilize the entire cross sectional area for combined bending and direct stress, and most codes do not permit such design. If such a condition seems warranted, the following formulae for f_c should be used:

$$f_c = \frac{N}{b'h}\left[\frac{1}{1+(n-1)\,p} + \frac{6he}{h^2+12\,(n-1)\,pa^2}\right]$$

When the first term in the brackets of the equation for Case 1 is larger than the second term, the minimum stress in the concrete is compression; when the two are equal the concrete stress is zero on the side opposite the thrust. When the second term is larger than the first the minimum stress is tension and if, as is ordinarily assumed, no tension is permitted in the concrete, the formula just used is not applicable. That given for tension on section will govern.

When using the curves for Case 1, if the point of intersection of the ratio $\frac{a}{d}$ and p falls outside the curve, or in other words beyond the line marked "zero compression", the curve for tension on section, Case 2, must be used.

The eccentricity, "e_0", producing zero compression is

$$e_0 = \frac{1 + 12\,(n - 1)\,p\left(\frac{a}{d}\right)^2}{6\,[1 + (n - 1)\,p]}$$

When the load or thrust is applied at a distance greater than "e_0", the steel must be designed to take the resulting tension.

CASE 2—Rectangular Section: Symmetrical Reinforcing.

TENSION ON SECTION. Based on net area, disregarding fireproofing.

When the eccentricity, "e", is so great that tension is produced in the section, the following formulae should be used:

$$N = \frac{f_c bd}{2}\;\frac{k^2 + 2npk - np}{k}$$

$$M = f_c bd^2\left[\frac{np}{k}\left(\frac{a}{d}\right)^2 + \frac{k}{4} - \frac{k^2}{6}\right] \qquad f_c = \frac{M}{\left[\frac{np}{k}\left(\frac{a}{d}\right)^2 + \frac{k}{4} - \frac{k^2}{6}\right]bd^2}$$

$f_s = nf_c\dfrac{1 - k}{k}$, which need not be computed if f_c is within limits.

In the above, "k" is unknown, and its derivation is a somewhat long and tedious process. By cut and try methods, assuming a value of "k", the corresponding value of $\frac{e}{d}$ may be found from

$$\frac{e}{d} = \frac{-k^3 + 1.5k^2 + 6np\left(\frac{a}{d}\right)^2}{3k^2 + 6npk - 3np}$$

By using the curves for Case 2, values of k for various ratios of $\frac{\text{"}e\text{"}}{d}$ and "p" are given direct in the upper graph and, with the known "k" and "p", the value of the constant K_2 is readily found in the lower graph. The value of f_c then becomes

$$f_c = \frac{M}{K_2 bd^2} \text{ and } M = K_2 f_c bd^2$$

CASE 3—Steel in Tension Side Only.

When a member with steel in the tension face only, such as a simple beam, is subject to bending and direct stress,, the gravity axis will not be at the center of the section. The depth from the top edge to the gravity axis, which we will call a_1, must be figured and is

$$a_1 = \frac{h}{2}\;\frac{1 + 2\,(n - 1)\,p\left(\frac{d}{h}\right)^2}{1 + (n - 1)\,p\left(\frac{d}{h}\right)^2} \text{ when full depth, "}h\text{", is considered.}$$

If the net depth is considered, "d" should be inserted in the above instead of $\frac{d}{h}$.

The compression in the concrete is

$$f_c = \frac{M}{bd^2\left[\frac{k}{2}\left(\frac{a_1}{d} - \frac{1}{3}k\right) + pn\frac{1 - k}{k}\left(1 - \frac{a_1}{d}\right)\right]} \text{ and } M = f_c bd^2$$

As in Case 2, it is tedious to figure "k". The value of $\frac{e}{d}$ for a known "k" is

$$\frac{e}{d} = \frac{k^2\left(\frac{a_1}{d} - \frac{1}{3}k\right) + 2pn\,(1 - k)\left(1 - \frac{a_1}{d}\right)}{k^2 - 2np\,(1 - k)}$$

The solution of the problem is, however, simplified as in previous cases by the use of curves giving values of "k", and a constant K_3. The compression in the concrete is

$$f_c = \frac{M}{K_3\,bd^2} \text{ and } f_s = nf_c\frac{1 - k}{k}$$

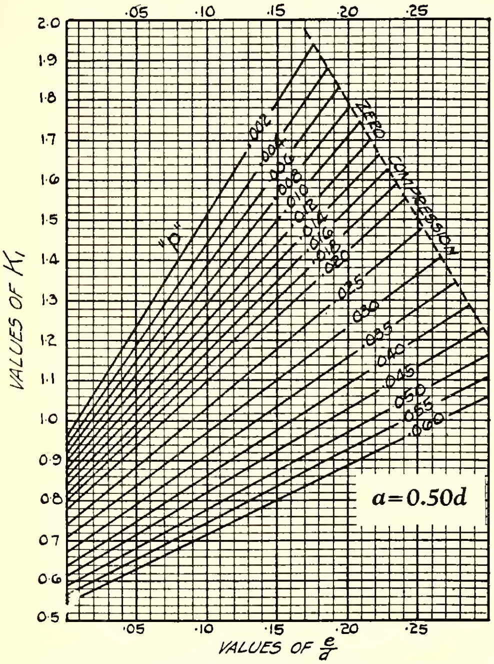
BENDING AND DIRECT STRESS

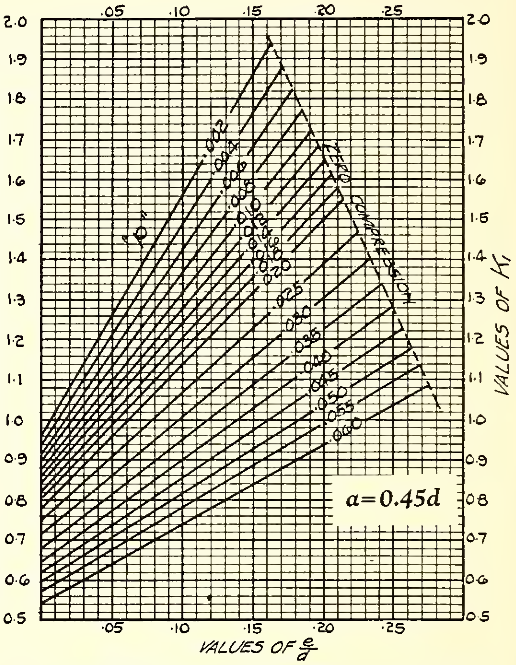
CASE 1.–COMPRESSION ON SECTION

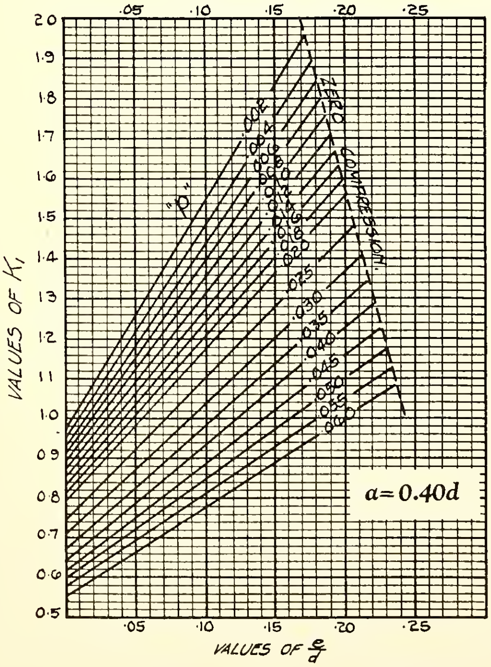
CONSTANT FOR f_c

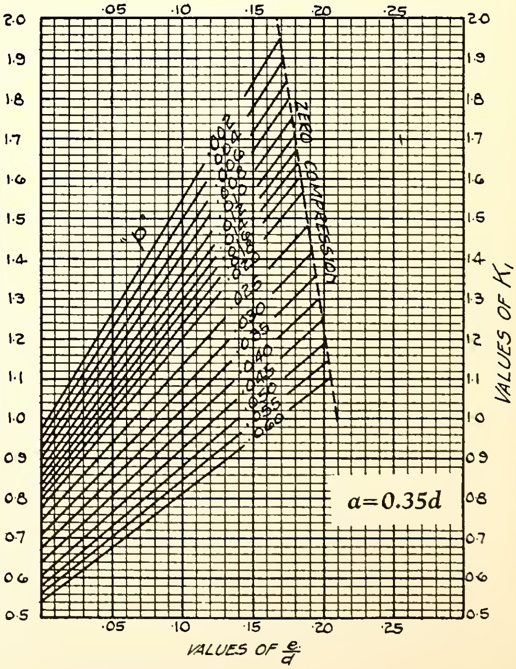
$f_c = K_1 \frac{N}{bd}$

$n = 15$









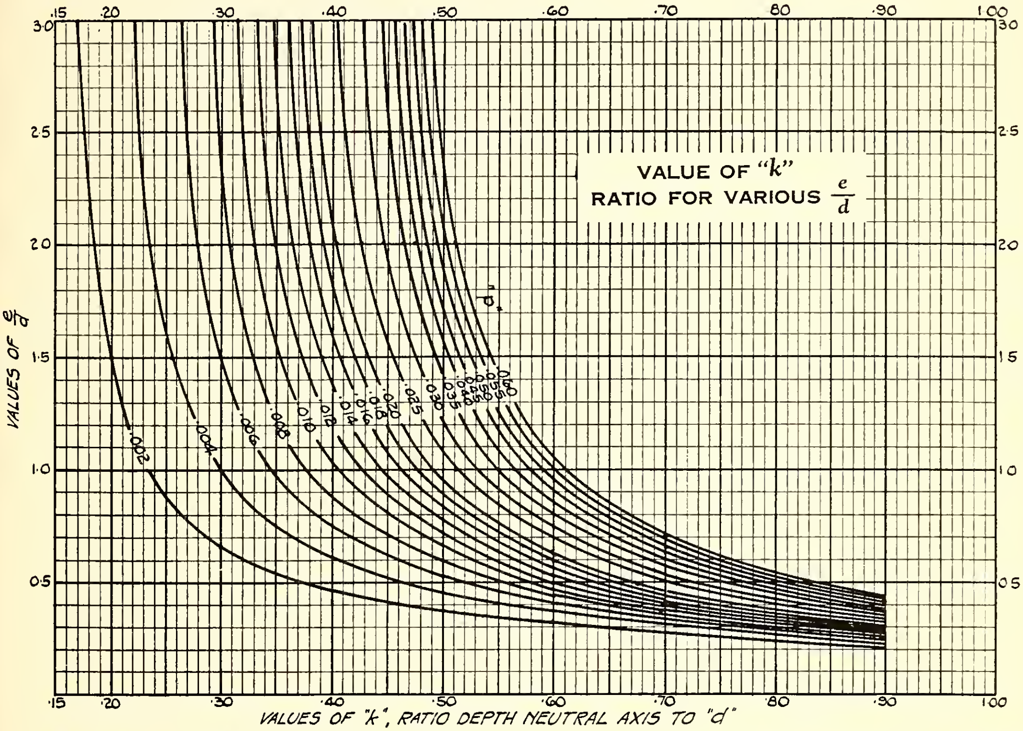
BENDING AND DIRECT STRESS

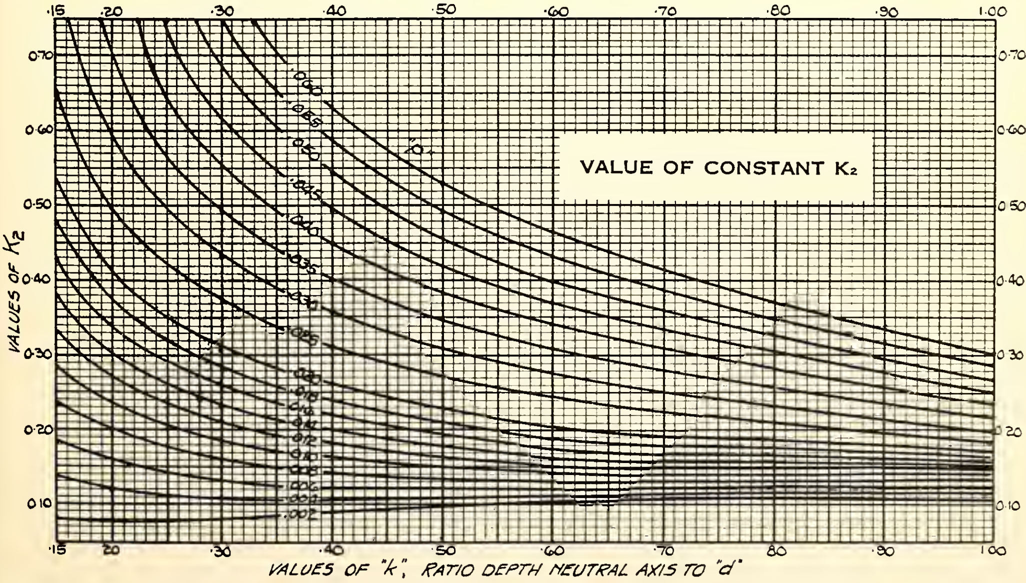
CASE 2.–TENSION ON SECTION

CONSTANT FOR f_c

$f_c = \frac{M}{K_2 bd^2}$

$n = 15$



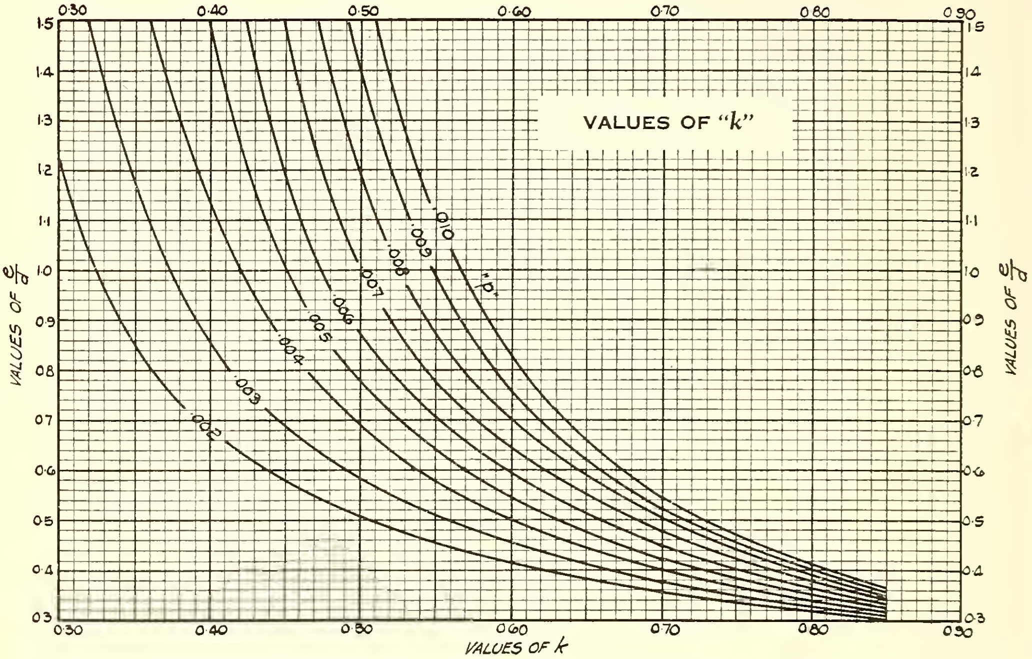


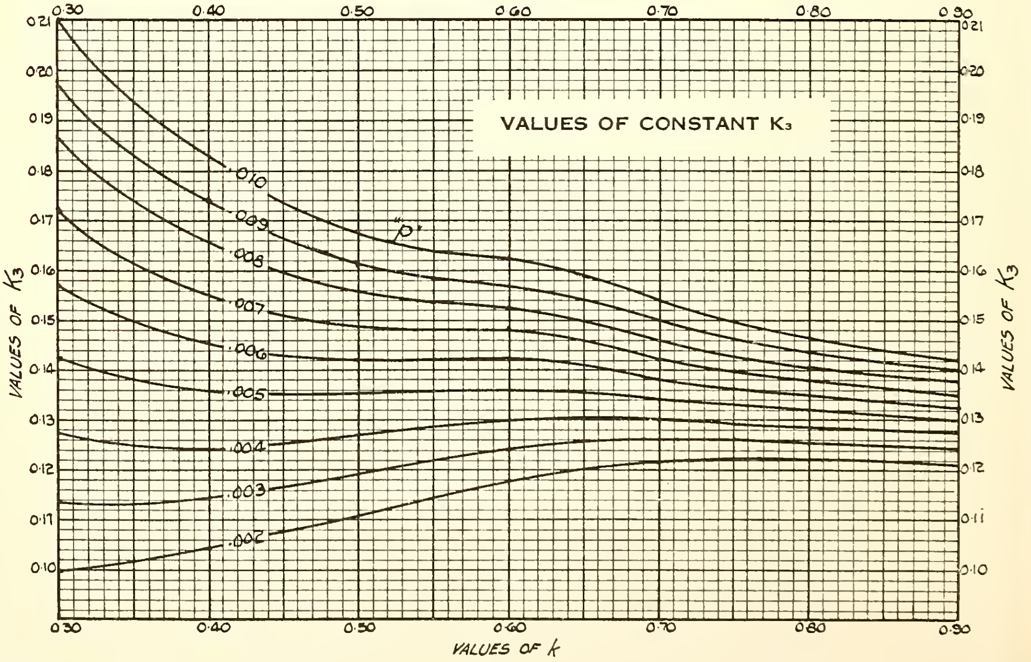
BENDING AND DIRECT STRESS

CASE 3.—REINFORCING IN TENSION SIDE ONLY

CONSTANT FOR f_c

$f_c = \frac{M}{K_3 bd^2}$ $n = 15$





SQUARE REINFORCED CONCRETE COLUMNS

WITH LATERAL TIES

$P = 0.225 f'_c A\,[1 + (n - 1)p]$
Min. p = .01 net area
Max. p = .06 net area

TAYLOR, THOMPSON & SMULSKI RECOMMENDATIONS

SIZE
12" to 30"
OUT TO OUT

STRESS ON NET AREA COLUMN SECTION

Col. Size	Weight Per Lin. Foot	No. Bars	Allowable Load in Kips—$f'_c = 2000$								Allowable Load in Kips—$f'_c = 2500$								Allowable Load in Kips—$f'_c = 3000$							
			½ φ	⅝ φ	¾ φ	⅞ φ	1 φ	1 □	1⅛ □	1¼ □	½ φ	⅝ φ	¾ φ	⅞ φ	1 φ	1 □	1⅛ □	1¼ □	½ φ	⅝ φ	¾ φ	⅞ φ	1 φ	1 □	1⅛ □	1¼ □
12"	150	4	34	37	40	44					41	44	47	51					48	51	54	58				
		6	36	40							43	47							50	54						
		8	39	44							46	51							53	58						
13"	176	4		44	48	52	56					53	57	60	65					62	65	69	74			
		6	44	48	53						53	57	62						62	66	71					
		8	46	52							55	61							64	70						
14"	204	4		53	56	60	65	70				64	67	71	76	81				75	78	82	87	92		
		6	52	57	62	68					64	68	73	79					75	79	84	89				
		8	55	60	67						66	72	78						77	82	89					
15"	234	4		62	66	70	74	80				76	79	83	88	93				89	92	96	101	106		
		6	62	66	71	77	84				75	79	85	90	97				89	93	98	104	110			
		8	64	70	77	85					78	83	90	98					91	97	103	111				
16"	267	4			76	80	85	90	97				92	96	101	106	112				108	112	116	122	128	
		6		76	81	88	94					93	98	103	110					108	113	119	126			
		8	75	80	87	95					91	96	103	111					107	112	119	126				
17"	301	4			87	91	96	101	108	115			106	110	115	120	127	134			125	129	133	138	145	152
		6		88	93	99	106	114				107	112	118	124	132				125	130	136	143	151		
		8		91	98	106	116					110	117	125	134					129	136	143	152			
18"	337	4				103	108	113	120	128				125	130	135	142	149				147	151	157	163	170
		6			105	111	118	126	136				127	133	139	148	157				148	154	161	169	178	
		8		104	110	119	128					126	132	140	149					147	154	162	170			
19"	376	4				116	121	126	133	141				141	146	152	158	165				166	171	176	183	190
		6			118	124	131	139	149				143	149	156	164	174				168	174	180	188	198	
		8		117	124	132	141	152				142	147	156	166	176				167	173	181	190	200		
20"	416	4					135	140	147	155					164	169	176	183					192	197	204	211
		6			132	138	145	153	163	174			161	166	173	181	191	202			189	195	201	209	219	230
		8			137	144	155	166	179				172	181	194	207	224				194	202	211	221	234	
21"	460	4					150	155	162	169					182	187	194	201					214	219	226	233
		6				153	160	168	178	189				185	192	200	210	221				217	224	232	241	252
		8			152	160	170	181	194				185	192	202	212	225				217	224	233	244	257	
		12		153	163	176	189	206	226			186	196	208	221	237	256			218	228	239	252	268	288	
22"	504	4						171	178	185						207	214	221						243	250	257
		6				169	176	184	194	205				205	212	220	229	241				241	247	255	265	276
		8			168	176	185	196	210	225			204	212	221	232	245	260			240	248	257	267	280	295
		12		169	179	191	205	221				205	215	227	241	257				241	251	263	276	292		
23"	550	4						188	194	202						228	235	242						268	274	282
		6				185	192	200	210	221				226	233	240	250	261				266	272	280	290	301
		8				193	202	213	226	241				233	242	253	266	281				273	282	292	305	320
		12		186.	196	208	222	238	258	280		226	236	248	261	279	297	319		266	276	288	301	316	336	357
24"	600	4						205	212	219						250	257	264						294	301	308
		6					210	218	228	239					254	262	272	283					299	306	316	327
		8				210	220	230	244	259				255	264	275	288	302				299	308	319	332	343
		12			213	226	239	256	276				258	270	284	300	319				302	314	327	343	362	
25"	652	4							230	238							280	287							328	336
		6					228	236	246	257					277	286	295	306					326	334	344	355
		8				229	238	249	262	277				278	287	298	311	326				327	336	346	359	374
		12			232	244	258	274	294				281	293	307	323	343				330	341	355	371	390	
26"	705	4							250	257							304	311							357	365
		6						256	266	277						310	320	331						363	373	384
		8					257	268	282	297					311	322	335	350					365	375	388	403
		12			251	263	277	294	314	344			305	317	331	347	367	389			359	370	384	400	419	441
27"	760	4								278								337								395
		6						276	286	297						335	345	356						393	403	414
		8					278	289	302	317					337	347	361	375					395	406	418	433
		12			271	284	297	314	334	356			331	343	356	372	392	414			389	401	414	430	450	471
28"	818	4								299								363								427
		6						297	307	318						361	371	382						425	435	446
		8					299	309	323	338					363	374	387	401					427	437	450	465
		12				305	319	335	355	377				369	383	399	419	440				433	446	462	481	503
29"	875	4								321								391								460
		6							329	340							399	410							468	479
		8					321	332	345	360					391	401	415	429					460	470	483	498
		12				327	341	357	377	399				397	410	426	446	468				466	479	495	514	536
30"	937	6							352	363							428	439							502	513
		8						355	368	383						430	443	458						505	518	532
		12				350	364	380	400	422				425	439	455	475	497				500	513	529	548	570

$P = Af_c[1 + (n-1)p]$
$f_c = 0.35f'_c$
Spacers not included in spiral weights

REINFORCED CONCRETE COLUMNS

WITH 1% SPIRAL HOOPING

TAYLOR, THOMPSON & SMULSKI RECOMMENDATION

CORE SIZE
12″ to 17″

Core Diam.	Wt. Per Ft. Inc. Fireproofing		% Vert. Bars	ALLOWABLE LOAD IN KIPS			A_s Sq. In.	NUMBER VERTICAL BARS FOR REQ'D A_s								SPIRAL			
	Round	Square		$f'_c=$ 2000	$f'_c=$ 2500	$f'_c=$ 3000		½ φ	⅝ φ	¾ φ	⅞ φ	1 φ	1 □	1⅛ □	1¼ □	Bar	Pitch	Diam.	Weight Per Ft.
12″	209	267	1	90	110	129	1.13	6								¼φ	1½	12	4.2
			1½	96	115	135	1.70	9	6										
			2	101	121	140	2.26	12	8	6									
			2½	107	126	145	2.83	15	10	7									
			3	112	132	151	3.39	17	11	8	6								
			3½	118	137	156	3.96	20	13	9	7								
			4	124	143	162	4.52		15	11	8	6							
			4½	129	148	167	5.09		17	12	9	7							
			5	135	153	172	5.65		19	13	10	8	6						
			5½	140	159	178	6.22			14	11	8	7						
			6	146	164	183	6.79			16	12	9	7						
13″	237	301	1	106	129	152	1.33	7								¼φ	1½	13	4.5
			1½	112	135	158	1.99	10	7										
			2	119	142	164	2.65	14	9	6									
			2½	125	148	171	3.32	17	11	8	6								
			3	132	154	177	3.98	20	13	9	7								
			3½	138	161	183	4.65		15	11	8	6							
			4	145	167	190	5.31		18	12	9	7							
			4½	151	174	196	5.97		20	14	10	8	6						
			5	158	180	202	6.64			15	11	9	7						
			5½	164	186	208	7.30			17	13	10	8	6					
			6	171	193	215	7.96			18	14	11	8	7					
14″	265	337	1	123	150	176	1.54	8	6							5/16φ	2	14	5.8
			1½	130	157	183	2.31	12	8	6									
			2	138	164	191	3.08	16	10	7									
			2½	145	172	198	3.85	20	13	9	7								
			3	153	179	205	4.62		15	11	8	6							
			3½	161	187	213	5.39		18	13	9	7							
			4	168	194	220	6.16		20	14	11	8	6						
			4½	176	201	227	6.93			16	12	9	7						
			5	183	209	234	7.70			18	13	10	8	6					
			5½	191	216	242	8.47			19	14	11	9	7					
			6	198	224	249	9.24				16	12	10	8	6				
15″	296	376	1	141	172	202	1.77	9	6							5/16φ	2	15	6.2
			1½	150	180	211	2.65	14	9	6									
			2	158	189	219	3.53	18	12	8	6								
			2½	167	197	227	4.42		15	10	8	6							
			3	176	206	236	5.30		18	12	9	7							
			3½	184	214	244	6.19		20	14	11	8	6						
			4	193	223	252	7.07			16	12	9	7	6					
			4½	202	231	261	7.95			18	13	10	8	7					
			5	210	240	269	8.84			20	15	12	9	7	6				
			5½	219	248	277	9.72				17	13	10	8	7				
			6	228	257	286	10.60				18	14	11	9	7				
16″	327	416	1	160	195	230	2.01	11	7							5/16φ	1¾	16	7.5
			1½	171	205	240	3.02	16	10	7									
			2	180	215	249	4.02	20	14	9	7								
			2½	190	224	259	5.03		17	12	9	7							
			3	200	234	268	6.03		20	14	10	8	6						
			3½	210	244	278	7.04			16	12	9	7						
			4	220	253	287	8.04			19	14	11	8	7					
			4½	229	263	297	9.05				15	12	9	8	6				
			5	239	273	306	10.05				17	13	10	8	7				
			5½	249	282	316	11.06				19	14	11	9	7				
			6	259	292	325	12.06				20	15	12	10	8				
17″	360	460	1	181	220	260	2.27	12	8							⅜φ	2½	17	8.0
			1½	192	231	271	3.40	18	11	8	6								
			2	203	242	281	4.54		15	11	8	6							
			2½	214	253	292	5.67		19	13	10	8	6						
			3	226	264	303	6.81			16	12	9	7						
			3½	237	275	313	7.94			18	14	11	8	7					
			4	248	286	324	9.08				16	12	9	8	6				
			4½	259	297	335	10.21				17	13	11	8	7				
			5	270	308	346	11.35				19	15	12	9	8				
			5½	281	319	356	12.48					16	13	10	8				
			6	292	330	367	13.62					18	14	11	9				

$P = Af_c[1 + (n - 1)p]$
$f_c = 0.35f'_c$

REINFORCED CONCRETE COLUMNS

WITH 1% SPIRAL HOOPING

TAYLOR, THOMPSON & SMULSKI RECOMMENDATION

CORE SIZE 18″ to 23″

Core Diam.	Wt. Per Ft. Inc. Fireproofing		% Vert. Bars	ALLOWABLE LOAD IN KIPS			A_s Sq. In.	NUMBER VERTICAL BARS FOR REQ'D A_s								SPIRAL			
	Round	Square		f'c= 2000	f'c= 2500	f'c= 3000		½ φ	⅝ φ	¾ φ	⅞ φ	1 φ	1 □	1⅛ □	1¼ □	Bar	Pitch	Diam.	Weight Per Ft.
18″	396	504	1	203	247	291	2.54	13	9	6						⅜φ	2½	18	8.51
			1½	216	259	303	3.82	20	13	9	7								
			2	228	272	315	5.09		17	12	9	7							
			2½	240	284	327	6.36			15	11	9	7						
			3	253	296	339	7.63			18	13	10	8	6					
			3½	265	308	351	8.91			20	15	12	9	7	6				
			4	278	321	363	10.18				17	13	10	8	7				
			4½	290	333	375	11.45				19	15	12	9	8				
			5	303	345	387	12.72					17	13	10	9				
			5½	315	357	399	14.00					18	14	12	9				
			6	328	370	411	15.27					20	16	13	10				
19″	432	550	1	226	275	324	2.84	15	10	7						⅜φ	2¼	19	9.99
			1½	240	289	338	4.25		14	10	7								
			2	254	303	351	5.67		19	13	10	8	6						
			2½	268	316	365	7.09			16	12	9	7	6					
			3	282	330	378	8.51			20	15	11	9	7	6				
			3½	296	344	391	9.92				17	13	10	8	7				
			4	310	357	405	11.34				19	15	12	9	8				
			4½	324	371	418	12.76					17	13	10	9				
			5	337	385	432	14.18					18	14	12	10				
			5½	351	398	445	15.59					20	16	13	10				
			6	365	412	458	17.01						17	14	11				
20″	471	600	1	251	305	360	3.14	16	11	8						⅜φ	2¼	20	10.50
			1½	266	320	374	4.71		16	11	8	6							
			2	281	335	389	6.28			15	11	8	7						
			2½	297	350	404	7.85			18	13	10	8	7					
			3	312	366	419	9.42				16	12	10	8	6				
			3½	328	381	434	11.00				19	14	11	9	7				
			4	343	396	449	12.57					16	13	10	8				
			4½	358	411	463	14.14					18	15	12	9				
			5	374	426	478	15.71					20	16	13	10				
			5½	389	441	493	17.28						18	14	11				
			6	405	456	508	18.85						19	15	12				
21″	512	652	1	276	336	396	3.46	18	12	8	6					⅜φ	2	21	12.41
			1½	293	353	413	5.20		17	12	9	7	6						
			2	310	370	429	6.93			16	12	9	7	6					
			2½	327	386	446	8.66			20	15	11	9	7	6				
			3	344	403	462	10.39				18	13	11	9	7				
			3½	361	420	478	12.12				20	16	13	10	8				
			4	378	436	495	13.85					18	14	11	9				
			4½	395	453	511	15.59					20	16	13	10				
			5	412	470	527	17.32						18	14	12				
			5½	429	486	544	19.05						19	15	13				
			6	446	503	560	20.78						21	17	14				
22″	553	705	1	303	369	435	3.80	20	13	9	7					⅜φ	2	22	13.01
			1½	322	387	453	5.70		19	13	10	8	6						
			2	341	406	471	7.60			18	13	10	8	6					
			2½	359	424	489	9.50				16	13	10	8	7				
			3	378	442	507	11.40				19	15	12	9	8				
			3½	396	461	525	13.30					17	14	11	9				
			4	415	479	543	15.21					20	16	12	10				
			4½	434	497	561	17.11						18	14	11				
			5	452	516	579	19.01						19	15	13				
			5½	471	534	597	20.91						21	17	14				
			6	490	552	615	22.81						23	18	15				
23″	598	760	1	332	404	476	4.15	21	14	10	7	6				⅜φ	2	23	13.59
			1½	352	424	495	6.23		21	15	11	8	7						
			2	372	444	515	8.31			19	14	11	9	7	6				
			2½	393	464	534	10.39				18	14	11	9	7				
			3	413	484	554	12.46				21	16	13	10	8				
			3½	433	504	574	14.54					19	15	12	10				
			4	454	523	593	16.62					22	17	14	11				
			4½	474	543	613	18.70						19	15	12				
			5	494	563	633	20.77						21	17	14				
			5½	515	583	652	22.85						23	18	15				
			6	535	603	672	24.93						25	20	16				

$P = Af_c[1 + (n-1)p]$
$f_c = 0.35f'_c$
* Denotes two lines of bars required.

REINFORCED CONCRETE COLUMNS

WITH 1% SPIRAL HOOPING

TAYLOR, THOMPSON & SMULSKI RECOMMENDATIONS

CORE SIZE 24" to 29"

Core Diam.	Wt. Per Ft. Inc. Fireproofing		% Vert. Bars	ALLOWABLE LOAD IN KIPS			A_s Sq. In.	NUMBER VERTICAL BARS FOR REQ'D A_s								SPIRAL			
	Round	Square		f'c= 2000	f'c= 2500	f'c= 3000		½ φ	⅝ φ	¾ φ	⅞ φ	1 φ	1 □	1⅛ □	1¼ □	Bar	Pitch	Diam.	Weight Per Ft.
24"	642	818	1	361	439	518	4.52		15	11	8	6				½φ	3	24	16.81
			1½	383	461	539	6.79		22	16	12	9	7	6					
			2	405	483	561	9.05			21	15	12	9	8	6				
			2½	428	505	582	11.31				19	15	12	9	8				
			3	450	526	603	13.57				23	18	14	11	9				
			3½	472	548	625	15.83					21	16	13	11				
			4	494	570	646	18.10					23	19	15	12				
			4½	516	592	667	20.36						21	16	13				
			5	538	614	689	22.62						23	18	15				
			5½	561	635	710	24.88						25	20	16				
			6	583	657	732	27.14						*28	22	18				
25"	690	875	1	392	477	562	4.91		16	11	9	7	6			½φ	3	25	17.51
			1½	416	500	585	7.36			17	13	10	8	6					
			2	440	524	608	9.82			23	17	13	10	8	7				
			2½	464	548	631	12.27				21	16	13	10	8				
			3	488	571	655	14.73				25	19	15	12	10				
			3½	512	595	678	17.18					22	18	14	11				
			4	536	619	701	19.63					25	20	16	13				
			4½	560	642	724	22.09						22	18	15				
			5	584	666	747	24.54						25	20	16				
			5½	608	689	771	27.00						*27	22	18				
			6	632	713	794	29.45						*30	*24	19				
26"	737	937	1	424	516	608	5.31		18	12	9	7	6			½φ	3	26	18.21
			1½	450	541	633	7.96			18	14	11	8	7					
			2	476	567	658	10.62			24	18	14	11	9	7				
			2½	502	592	683	13.27				22	17	14	11	9				
			3	528	618	708	15.93				27	21	16	13	11				
			3½	554	643	733	18.58					24	19	15	12				
			4	580	669	758	21.24					27	22	17	14				
			4½	606	695	783	23.89						24	19	16				
			5	632	720	808	26.55						27	21	17				
			5½	658	746	833	29.20						*30	23	19				
			6	684	771	859	31.86						*32	*25	21				
27"	788	1000	1	457	556	655	5.73		19	13	10	8	6			½φ	2¾	27	20.63
			1½	485	584	682	8.59			20	15	11	9	7	6				
			2	513	611	709	11.45			26	19	15	12	10	8				
			2½	541	639	736	14.31				24	19	15	12	10				
			3	569	666	764	17.18				29	22	18	14	11				
			3½	597	694	791	20.04					26	20	16	13				
			4	625	721	818	22.90					29	23	18	15				
			4½	653	749	845	25.76						26	21	17				
			5	681	777	872	28.63						*29	23	19				
			5½	709	804	899	31.49						*32	25	21				
			6	737	832	926	34.35						*35	*27	22				
28"	838	1068	1	491	598	705	6.16		20	14	11	8	7	6		½φ	2¾	28	21.40
			1½	522	628	734	9.24			21	16	12	10	8	6				
			2	552	657	763	12.32			28	21	16	13	10	8				
			2½	582	687	792	15.39				26	20	16	13	10				
			3	612	717	821	18.47					24	19	15	12				
			3½	642	746	850	21.55					28	22	17	14				
			4	672	776	879	24.63						25	20	16				
			4½	703	805	908	27.71						28	22	18				
			5	733	835	937	30.79						*31	25	20				
			5½	763	865	967	33.87						*34	*27	22				
			6	793	894	996	36.95						*37	*30	*24				
29"	890	1135	1	527	642	756	6.61			15	11	9	7	6		½φ	2¾	29	22.16
			1½	559	673	787	9.91			23	17	13	10	8	7				
			2	592	705	818	13.21			30	22	17	14	11	9				
			2½	624	737	850	16.51				28	21	17	13	11				
			3	657	769	881	19.82				33	26	20	16	13				
			3½	689	800	912	23.12					30	24	19	15				
			4	721	832	943	26.42					34	27	21	17				
			4½	754	864	974	29.72						30	24	19				
			5	786	896	1006	33.03						*33	26	22				
			5½	818	928	1037	36.33						*37	*29	24				
			6	851	959	1068	39.63						*40	*32	*26				

$P = Af_c[1 + (n - 1)p]$
$f_c = 0.35f'_c$
* Denotes two lines of bars required.

REINFORCED CONCRETE COLUMNS

WITH 1% SPIRAL HOOPING

TAYLOR, THOMPSON & SMULSKI RECOMMENDATIONS

CORE SIZE
30" to 35"

Core Diam.	Wt. Per Ft. Inc. Fireproofing		% Vert. Bars	ALLOWABLE LOAD IN KIPS			A_s Sq. In.	NUMBER VERTICAL BARS FOR REQ'D A_s								SPIRAL			
	Round	Square		$f'_c = 2000$	$f'_c = 2500$	$f'_c = 3000$		½ φ	⅝ φ	¾ φ	⅞ φ	1 φ	1 □	1⅛ □	1¼ □	Bar	Pitch	Diam.	Weight Per Ft.
30"	945	1200	1	564	687	809	7.07			16	12	9	7	6		½φ	2½	30	25.22
			1½	599	721	842	10.60			24	18	14	11	9	7				
			2	633	755	876	14.14				24	18	15	12	9				
			2½	668	789	909	17.67				30	23	18	14	12				
			3	703	823	943	21.21				36	27	22	17	14				
			3½	737	857	976	24.74					32	25	20	16				
			4	772	891	1009	28.27					36	29	23	19				
			4½	807	925	1043	31.81						*32	26	21				
			5	841	959	1076	35.34						*36	28	23				
			5½	876	993	1110	38.88						*39	*31	25				
			6	910	1027	1143	42.41						*43	*34	*28				
31"	1000	1280	1	602	733	864	7.55			17	13	10	8	6		½φ	2½	31	26.06
			1½	639	769	899	11.32			26	19	15	12	9	8				
			2	676	806	935	15.10				26	20	16	12	10				
			2½	713	842	971	18.87				32	24	19	15	13				
			3	750	878	1006	22.64					29	23	18	15				
			3½	787	915	1042	26.42					34	27	21	17				
			4	824	951	1078	30.19					39	31	24	20				
			4½	861	987	1113	33.96						*34	27	22				
			5	898	1024	1149	37.74						*38	*30	25				
			5½	935	1060	1185	41.51						*42	*33	*27				
			6	972	1096	1220	45.29						*46	*36	*29				
32"	1060	1350	1	642	781	920	8.04			19	14	11	8	7	6	½φ	2¼	32	29.89
			1½	681	820	958	12.06			28	20	16	12	10	8				
			2	721	859	996	16.08				27	21	16	13	11				
			2½	760	897	1034	20.11				34	26	21	16	13				
			3	799	936	1072	24.13					31	25	19	16				
			3½	839	975	1110	28.15					36	29	23	18				
			4	878	1013	1148	32.17						33	26	21				
			4½	918	1052	1186	36.19						*37	29	24				
			5	957	1091	1224	40.21						*41	*32	26				
			5½	996	1129	1262	44.23						*45	*35	*29				
			6	1036	1168	1300	48.25						*49	*38	*31				
33"	1120	1425	1	683	831	979	8.55			20	15	11	9	7	6	½φ	2¼	33	30.82
			1½	724	872	1019	12.83			29	22	17	13	11	9				
			2	766	913	1060	17.11				29	22	18	14	11				
			2½	808	954	1100	21.38				36	28	22	17	14				
			3	850	995	1141	25.66					33	26	21	17				
			3½	892	1037	1181	29.94					39	30	24	20				
			4	934	1078	1221	34.21						*35	27	22				
			4½	976	1119	1262	38.49						*39	31	25				
			5	1018	1160	1302	42.76						*43	*34	28				
			5½	1060	1201	1343	47.04						*47	*37	*31				
			6	1102	1242	1383	51.32						*52	*41	*33				
34"	1180	1505	1	725	882	1039	9.08			21	15	12	9	8	6	½φ	2¼	34	31.76
			1½	769	926	1082	13.62				23	18	14	11	9				
			2	813	969	1125	18.16				31	23	19	15	12				
			2½	858	1013	1168	22.70					29	23	18	15				
			3	902	1057	1211	27.24					35	28	22	18				
			3½	947	1100	1254	31.78						32	25	21				
			4	991	1144	1297	36.32						*37	29	24				
			4½	1036	1188	1339	40.86						*41	*33	27				
			5	1080	1231	1382	45.40						*46	*36	*30				
			5½	1125	1275	1425	49.94						*50	*40	*32				
			6	1169	1319	1468	54.48						*55	*43	*35				
35"	1245	1585	1	768	934	1101	9.62			22	16	13	10	8	7	½φ	2¼	35	32.69
			1½	815	981	1147	14.43				24	19	15	12	10				
			2	862	1027	1192	19.24				32	25	20	16	13				
			2½	909	1073	1238	24.05					31	24	19	16				
			3	956	1120	1283	28.86					37	29	23	19				
			3½	1003	1166	1328	33.67						34	27	22				
			4	1051	1212	1374	38.48						*39	31	25				
			4½	1098	1259	1419	43.30						*44	*34	28				
			5	1145	1305	1465	48.11						*49	*38	*31				
			5½	1192	1351	1510	52.92						*53	*42	*34				
			6	1239	1397	1556	57.73						*58	*46	*37				

$P = Af_c[1 + (n - 1)p]$
$f_c = 0.35f'_c$
* Denotes two lines of bars required.

REINFORCED CONCRETE COLUMNS
WITH 1% SPIRAL HOOPING
TAYLOR, THOMPSON & SMULSKI RECOMMENDATIONS

CORE SIZE
36" to 41"

Core Diam.	Wt. Per Ft. Inc. Fireproofing		% Vert. Bars	ALLOWABLE LOAD IN KIPS			A_s Sq. In.	NUMBER VERTICAL BARS FOR REQ'D A_s								SPIRAL			
	Round	Square		$f'_c=$ 2000	$f'_c=$ 2500	$f'_c=$ 3000		½ φ	⅝ φ	¾ φ	⅞ φ	1 φ	1 □	1⅛ □	1¼ □	Bar	Pitch	Diam.	Weight Per Ft.
36"	1310	1667	1	812	989	1165	10.18			23	17	13	11	8	7	½φ	2	36	37.79
			1½	862	1038	1213	15.27				26	20	16	13	10				
			2	912	1087	1261	20.36				34	26	21	16	13				
			2½	962	1136	1309	25.45					33	26	20	17				
			3	1012	1185	1357	30.54					39	31	24	20				
			3½	1062	1234	1405	35.63						36	28	23				
			4	1112	1283	1454	40.72						*41	32	27				
			4½	1161	1332	1502	45.80						*46	*36	30				
			5	1211	1380	1550	50.89						*51	*40	*33				
			5½	1261	1429	1598	55.98						*56	*44	*36				
			6	1311	1478	1646	61.07						*61	*48	*40				
37"	1375	1750	1	858	1044	1231	10.75			25	18	14	11	9	7	½φ	2	37	38.88
			1½	911	1096	1281	16.13				27	21	17	13	11				
			2	963	1148	1332	21.50				36	28	22	17	14				
			2½	1016	1200	1383	26.88					34	27	22	18				
			3	1069	1251	1434	32.26					41	33	26	21				
			3½	1121	1303	1485	37.63						38	30	25				
			4	1174	1355	1535	43.01						*43	34	28				
			4½	1227	1407	1586	48.38						*49	*38	31				
			5	1279	1458	1637	53.76						*54	*43	*35				
			5½	1332	1510	1688	59.14						*60	*47	*38				
			6	1385	1562	1739	64.51						*65	*51	*42				
38"	1440	1835	1	905	1102	1298	11.34			26	19	15	12	9	8	½φ	2	38	39.93
			1½	961	1156	1352	17.01				29	22	17	14	11				
			2	1016	1211	1405	22.68				38	29	23	18	15				
			2½	1072	1265	1459	28.35					36	29	23	19				
			3	1127	1320	1512	34.02					44	34	27	22				
			3½	1183	1374	1566	39.69						40	32	26				
			4	1238	1429	1620	45.36						*46	*36	30				
			4½	1294	1484	1673	51.03						*51	*41	*33				
			5	1350	1538	1727	56.71						*57	*45	*37				
			5½	1405	1593	1780	62.38						*63	*50	*40				
			6	1461	1647	1834	68.05						*69	*54	*44				
39"	1515	1925	1	953	1160	1367	11.95			27	20	16	12	10	8	½φ	2	39	40.98
			1½	1012	1218	1424	17.92				30	23	18	15	12				
			2	1070	1275	1480	23.89				40	31	24	19	16				
			2½	1129	1333	1537	29.86					38	30	24	20				
			3	1187	1390	1593	35.84					46	36	29	23				
			3½	1246	1448	1649	41.81						*42	33	27				
			4	1304	1505	1706	47.78						*48	*38	31				
			4½	1363	1563	1762	53.76						*54	*43	*35				
			5	1422	1620	1819	59.73						*60	*48	*39				
			5½	1480	1678	1875	65.70						*66	*52	*43				
			6	1539	1735	1932	71.68						*72	*57	*46				
40"	1585	2020	1	1003	1221	1438	12.57			29	21	16	13	10	8	⅝φ	3	40	43.80
			1½	1064	1281	1498	18.85				32	24	19	15	13				
			2	1126	1341	1557	25.13				42	32	26	20	17				
			2½	1188	1402	1616	31.42					40	32	25	21				
			3	1249	1462	1676	37.70					48	38	30	25				
			3½	1311	1523	1735	43.98						*44	35	29				
			4	1372	1583	1794	50.27						*51	*40	33				
			4½	1434	1644	1854	56.55						*57	*45	*37				
			5	1495	1704	1913	62.83						*63	*50	*41				
			5½	1557	1765	1973	69.12						*70	*55	*45				
			6	1619	1825	2032	75.40						*76	*60	*49				
41"	1655	2110	1	1054	1282	1511	13.20			30	22	17	14	11	9	⅝φ	3	41	44.90
			1½	1118	1346	1573	19.80				33	26	20	16	13				
			2	1183	1409	1636	26.41				44	34	27	21	17				
			2½	1248	1473	1698	33.01					42	33	26	22				
			3	1312	1536	1761	39.61						40	32	26				
			3½	1377	1600	1823	46.21						*47	37	30				
			4	1442	1664	1885	52.81						*53	*42	34				
			4½	1506	1727	1948	59.41						*60	*47	*39				
			5	1571	1791	2010	66.01						*66	*52	*43				
			5½	1636	1854	2072	72.61						*73	*58	*47				
			6	1700	1918	2135	79.22						*80	*63	*51				

P = 0.80 Ag. (0.225 f'c + fs pg)
Ag = D² Pg = As/Ag.
fs = 16000 p.s.i.

SQUARE REINFORCED CONCRETE COLUMNS

WITH LATERAL TIES

A. C. I. SPECIFICATIONS — 1941

COLUMN SIZE D x D	GROSS AREA AG.	No. OF VERT. BARS	ALLOWABLE AXIAL LOAD — KIPS													
			f'c = 2000							f'c = 2500						
			⅝ φ	¾ φ	⅞ φ	1" φ	1" □	1⅛ □	1¼ □	⅝ φ	¾ φ	⅞ φ	1" φ	1" □	1⅛ □	1¼ □
10x10	100	4	51	58	66	76	87			60	67	75	85	96		
		6	59	69	82					68	78	91				
		8	67	81						76	90					
11x11	121	4	59	66	74	83	94			70	77	85	94	105		
		6	67	77	89					77	88	100				
		8	74	88						85	99					
12x12	144	4	67	74	82	92	103	116		80	87	95	104	116	129	
		6	75	85	98	112				88	98	111	125			
		8	83	97	113					96	109	126				
13x13	169	4	76	83	91	101	112	125	140	91	98	106	116	127	140	156
		6	84	94	107	121	137			99	109	122	136	152		
		8	92	106	122	141				107	121	137	156			
14x14	196	4	86	93	101	110	121	135	150	103	110	119	128	139	152	168
		6	94	104	116	130	147	167		111	122	134	148	165	185	
		8	101	115	132	150				119	133	149	168			
15x15	225	4	96	103	111	121	132	145	161	117	123	132	141	152	166	181
		6	104	114	127	141	157	178		124	135	147	161	178	198	
		8	112	126	142	161	183			132	146	162	181	203		
16x16	256	4		114	123	132	143	156	172		137	146	155	166	179	195
		6	115	126	138	152	168	189	212	138	149	161	175	192	212	235
		8	123	137	153	172	194	221		146	160	176	195	217	244	
17x17	289	4		126	134	144	155	168	184		152	160	170	181	194	210
		6	127	137	150	164	180	201	224	153	163	176	190	206	227	250
		8	135	149	165	184	206	233		161	175	191	210	232	259	
18x18	324	4		139	147	156	167	181	196		168	176	185	197	210	225
		6	140	150	162	176	193	213	236	169	179	192	206	222	242	265
		8	148	161	177	197	219	246	276	177	190	207	226	248	275	305
19x19	361	4			160	170	181	194	209			193	202	213	227	242
		6	153	163	176	190	206	227	250	186	196	208	222	239	259	282
		8	161	175	191	210	232	259	289	193	207	223	242	264	292	322
20x20	400	4			174	184	195	208	224			210	220	231	244	260
		6		177	190	204	220	241	264		213	226	240	256	277	300
		8	175	189	205	224	246	273	304	211	225	241	260	282	309	340
21x21	441	4			189	198	209	223	238			229	238	249	263	278
		6		192	204	219	235	255	278		232	244	258	275	295	318
		8	190	203	220	239	261	288	318	229	243	259	278	300	328	358
22x22	484	4				214	225	239	254				257	269	282	297
		6		208	220	234	251	271	294		251	264	278	294	314	337
		8	205	219	235	254	276	303	334	249	262	279	298	320	347	377
23x23	529	4				230	241	255	270				278	289	302	318
		6		224	236	250	267	287	310		271	284	298	314	335	358
		8		235	251	270	292	319	350		283	299	318	340	367	398
24x24	576	4				247	258	272	287				299	310	323	339
		6			253	267	284	304	327			305	319	336	356	379
		8		252	268	287	309	336	367		304	320	339	361	388	419
26x26	676	4					294	308	323					355	368	384
		6			289	303	320	340	363			350	364	381	401	424
		8		288	304	323	345	372	403		349	365	384	406	433	464
28x28	784	4					333	347	362					404	417	432
		6				342	359	379	402				413	429	449	472
		8			343	362	384	411	442			414	433	455	482	512
30x30	900	4						388	404						469	485
		6				384	400	421	444				465	481	502	525
		8			385	404	426	453	484			466	485	507	534	565

COLUMN SIZE D x D	GROSS AREA AG.	No. OF VERT. BARS	ALLOWABLE AXIAL LOAD — KIPS													
			f'c = 3000							f'c = 3750						
			⅝ φ	¾ φ	⅞ φ	1" φ	1" □	1⅛ □	1¼ □	⅝ φ	¾ φ	⅞ φ	1" φ	1" □	1⅛ □	1¼ □
10x10	100	4	69	76	84	94	105			83	90	98	107	118		
		6	77	87	100					91	101	113				
		8	85	99						98	112					
11x11	121	4	81	87	96	105	116			97	104	112	121	132		
		6	88	99	111					105	115	127				
		8	96	110						113	126					
12x12	144	4	93	100	108	117	128	142		112	119	128	137	148	161	
		6	101	111	123	138				120	131	143	157			
		8	109	122	139					128	142	158				
13x13	169	4	107	113	122	131	142	156	171	129	136	144	154	165	178	194
		6	114	125	137	151	168			137	148	160	174	190		
		8	122	136	152	171				145	159	175	194			
14x14	196	4	121	128	136	146	157	170	185	148	154	163	172	183	197	212
		6	129	139	152	166	182	202		155	166	178	192	209	229	
		8	137	151	167	186				163	177	193	212			
15x15	225	4	137	144	152	161	172	186	201	167	174	182	192	203	216	231
		6	145	155	167	181	198	218		175	185	198	212	228	249	
		8	152	166	182	201	223			183	197	213	232	254		
16x16	256	4		160	169	178	189	203	218		195	203	212	224	237	252
		6	161	172	184	198	215	235	258	196	206	219	233	249	269	292
		8	169	183	199	218	240	267		204	217	234	253	275	302	
17x17	289	4		178	186	196	207	220	236		217	225	235	246	259	275
		6	179	189	202	216	232	253	276	218	229	241	255	271	292	315
		8	187	201	217	236	258	285		226	240	256	275	297	324	
18x18	324	4		197	205	215	226	239	254		241	249	258	269	283	298
		6	198	208	221	235	251	272	295	242	252	264	278	295	315	338
		8	206	220	236	255	277	304	334	250	263	280	299	321	348	378
19x19	361	4			225	235	246	259	274			274	283	294	308	323
		6	218	228	241	255	271	292	315	267	277	289	303	320	340	363
		8	226	240	256	275	297	324	354	275	288	305	324	346	373	403
20x20	400	4			246	256	267	280	296			300	310	321	334	350
		6		249	262	276	292	313	336		303	316	330	346	367	390
		8	247	261	277	296	318	345	376	301	315	331	350	372	399	430
21x21	441	4			269	278	289	302	318			328	337	348	362	377
		6		272	284	298	314	335	358		331	343	357	374	394	417
		8	269	283	299	318	340	367	398	329	342	359	378	400	427	457
22x22	484	4				301	312	326	341				366	377	391	406
		6		295	307	321	338	358	381		360	372	386	403	423	446
		8	292	306	322	341	363	390	421	358	371	388	407	429	456	486
23x23	529	4				325	336	350	365				397	408	421	437
		6		319	331	345	362	382	405		391	403	417	433	454	477
		8		330	347	366	388	415	445		402	418	437	459	486	517
24x24	576	4				351	362	375	391				428	440	453	468
		6			357	371	387	408	431			435	449	465	485	508
		8		356	372	391	413	440	471		433	450	469	491	518	548
26x26	676	4					416	429	445					507	521	536
		6			411	425	441	462	485			502	516	533	553	576
		8		410	426	445	467	494	525		501	517	536	558	585	616
28x28	784	4					474	488	503					580	593	609
		6				483	500	520	543				589	606	626	649
		8			484	503	525	552	583			590	609	631	658	689
30x30	900	4						550	566						672	687
		6				546	562	583	606				667	684	704	727
		8			547	566	588	615	646			668	687	709	737	767

Loads to left of line --- for Pg = .005 to .01
Loads between lines ---- and —— for Pg = .01 to .02
Loads to right of line —— for Pg = .02 to .04

Use loads to left of line ···· for columns whose cross section is larger, for architectural reasons, than is required for loading conditions.

REINFORCED CONCRETE COLUMNS
WITH SPIRALS
A. C. I. SPECIFICATION — 1941

$P = A_g(0.225\, f'c + f_s P_g)$
$A_g = \pi D^2/4$ $P_g = A_s/A_g$.
$f_s = 16000$ p.s.i.

P' = Ratio volume spiral reinf. to volume concrete core.
Min. $P' = 0.45\,(A_g/A_c - 1)\, f'c/f's$
or Min. $P' = 0.0112$
$f's = 40{,}000$ p.s.i.

ALLOWABLE AXIAL LOAD — KIPS

COLUMN SIZE D	CORE DIAM.	GROSS AREA AG.	f′c = 2000										
			No. VERT. BARS	5/8 ϕ	3/4 ϕ	7/8 ϕ	1″ ϕ	1″ □	1 1/8 □	1 1/4 □	SPIRAL BAR	SPIRAL PITCH	SPIRAL DIAM.
14	11	154	6	98	111	127	144	165	190	219	$\frac{3}{8}''\phi$	$2\frac{3}{4}$	11
			7	103	118	136	157	181	211	244			
			8	108	125	146	169	197	231				
			9	113	132	155	182	218	251				
			10	118	139	165	194	229					
			11	123	147	175	207	245					
			12	128	154	184	220						
			13	133	161	194	232						
			14	138	168	203							
			15	142	175	213							
15	12	177	6	108	121	137	154	175	201	229	$\frac{3}{8}''\phi$	$2\frac{3}{4}$	12
			7	113	129	146	167	191	221	254			
			8	118	136	156	180	207	241	279			
			9	123	143	166	192	223	261	304			
			10	128	150	175	205	239	282				
			11	133	157	185	217	255	302				
			12	138	164	194	230	271					
			13	143	171	204	242						
			14	148	178	214	255						
			15	153	185	223	268						
16	13	201	6		132	148	165	186	211	240	$\frac{3}{8}''\phi$	$2\frac{3}{4}$	13
			7	124	139	157	178	202	232	265			
			8	129	147	167	191	218	252	290			
			9	134	154	177	203	234	272	315			
			10	139	161	186	216	250	292	340			
			11	144	168	196	228	266	313				
			12	149	175	205	241	282	333				
			13	154	182	215	253	298					
			14	159	189	225	266						
			15	164	196	234	278						
17	14	227	6		144	159	177	198	223	252	$\frac{3}{8}''\phi$	$2\frac{3}{4}$	14
			7		151	169	190	214	243	277			
			8	141	158	179	202	230	264	302			
			9	146	165	188	215	246	284	327			
			10	151	172	198	227	262	304	352			
			11	156	179	207	240	278	324	377			
			12	161	186	217	252	294	345				
			13	165	194	227	265	310	365				
			14	170	201	236	278	326					
			15	175	208	246	290						
			16	180	215	256	303						
			17	185	222	265	315						
18	15	254	6		156	172	189	210	236	264	$\frac{3}{8}''\phi$	$2\frac{1}{2}$	15
			7		164	181	202	226	256	289			
			8		171	191	215	242	276	314			
			9	158	178	201	227	258	296	339			
			10	163	185	210	240	274	317	364			
			11	168	192	220	252	290	337	389			
			12	173	199	229	265	306	357	414			
			13	178	206	239	277	322	377				
			14	183	213	249	290	338					
			15	188	220	258	303	354					
			16	193	227	268	315						
			17	197	234	278	328						

COLUMN SIZE D	CORE DIAM.	GROSS AREA AG.	f′c = 2500										
			No. VERT. BARS	5/8 ϕ	3/4 ϕ	7/8 ϕ	1″ ϕ	1″ □	1 1/8 □	1 1/4 □	SPIRAL BAR	SPIRAL PITCH	SPIRAL DIAM.
14	11	154	6	116	129	144	161	182	208	236	$\frac{3}{8}''\phi$	$2\frac{1}{4}$	11
			7	120	136	153	174	198	228	261			
			8	125	143	163	187	214	248				
			9	130	150	173	199	230	268				
			10	135	157	182	212	246					
			11	140	164	192	224	262					
			12	145	171	202	237						
			13	150	178	211	249						
			14	155	185	221							
			15	160	192	230							
15	12	177	6	128	141	157	174	195	220	249	$\frac{3}{8}''\phi$	$2\frac{1}{4}$	12
			7	133	148	166	187	211	241	274			
			8	138	155	176	199	227	261	299			
			9	143	163	185	212	243	281	324			
			10	148	170	195	225	259	301				
			11	153	177	205	237	275	322				
			12	158	184	214	250	291					
			13	163	191	224	262						
			14	168	198	234	275						
			15	173	205	243	287						
16	13	201	6		155	170	188	209	234	263	$\frac{3}{8}''\phi$	$2\frac{1}{4}$	13
			7	147	162	180	201	225	254	288			
			8	152	169	190	213	241	275	313			
			9	157	176	199	226	257	295	338			
			10	162	183	209	238	273	315	363			
			11	167	190	218	251	289	335				
			12	172	197	228	263	305	356				
			13	176	204	238	276	321					
			14	181	212	247	289						
			15	186	219	257	301						
17	14	227	6		170	185	203	223	249	277	$\frac{3}{8}''\phi$	$2\frac{1}{4}$	14
			7		177	195	215	239	269	302			
			8	166	184	204	228	255	289	327			
			9	171	191	214	240	271	309	352			
			10	176	198	223	253	287	330	377			
			11	181	206	233	265	303	350	402			
			12	186	212	243	278	319	370				
			13	191	219	252	291	335	390				
			14	196	226	262	303	351					
			15	201	233	271	316						
			16	206	240	281	328						
			17	211	247	291	341						
18	15	254	6		185	200	218	239	264	293	$\frac{3}{8}''\phi$	$2\frac{1}{4}$	15
			7		192	210	231	255	284	318			
			8		199	220	243	271	305	343			
			9	187	206	229	256	287	325	368			
			10	192	213	239	268	303	345	393			
			11	197	220	248	281	319	365	418			
			12	202	227	258	293	335	386	443			
			13	206	235	268	306	351	406				
			14	211	242	277	319	367					
			15	216	249	287	331	383					
			16	221	256	297	344						
			17	226	263	306	356						

Loads to left of line ---- for Pg = .01 to .04
Loads between lines ---- and —— for Pg = .04 to .06
Loads to right of line —— for Pg = .06 to .08

Maximum number of vertical bars limited by allowable spacing of bars within the periphery of the column core.

REINFORCED CONCRETE COLUMNS
WITH SPIRALS
A. C. I. SPECIFICATION — 1941

$P = Ag(0.225\,f'c + fs\,Pg)$
$Ag = \pi D^2/4 \qquad Pg = As/Ag.$
$fs = 16000$ p.s.i.

P′ = Ratio volume spiral reinf. to volume concrete core.
Min. $P' = 0.45\,(Ag/Ac - 1)\,f'c/f's$
or Min. $P' = 0.0112$
$f's = 40{,}000$ p.s.i.

COLUMN SIZE D	CORE DIAM.	GROSS AREA AG.	ALLOWABLE AXIAL LOAD — KIPS																					
			f′c = 3000											f′c = 3750										
			No. VERT. BARS	5/8 φ	3/4 φ	7/8 φ	1″ φ	1″ □	1 1/8 □	1 1/4 □	SPIRAL			No. VERT. BARS	5/8 φ	3/4 φ	7/8 φ	1″ φ	1″ □	1 1/8 □	1 1/4 □	SPIRAL		
											BAR	PITCH	DIAM.									BAR	PITCH	DIAM.
14	11	154	6	133	146	161	179	199	225	253	3/8″φ	2	11	6	159	172	187	205	225	251	279	1/2″φ	2 3/4	11
			7	138	153	171	191	215	245	278				7	164	179	197	217	241	271	304			
			8	143	160	180	204	231	265					8	169	186	206	230	257	291				
			9	148	167	190	217	247	286					9	174	193	216	242	273	312				
			10	153	174	200	229	263						10	178	200	226	255	289					
			11	157	181	209	242	279						11	183	207	235	268	305					
			12	162	188	219	254							12	188	214	245	280						
			13	167	195	228	267							13	193	221	254	293						
			14	172	202	238								14	198	228	264							
			15	177	209	248								15	203	235	274							
15	12	177	6	148	161	177	194	215	240	269	3/8″φ	2	12	6	178	191	206	224	245	270	299	1/2″φ	2 3/4	12
			7	153	168	186	207	231	261	294				7	183	198	216	237	261	290	324			
			8	158	175	196	219	247	281	319				8	188	205	226	249	277	311	349			
			9	163	182	205	232	263	301	344				9	193	212	235	262	293	331	374			
			10	168	189	215	244	279	321					10	198	219	245	274	309	351				
			11	173	197	225	257	295	342					11	203	226	254	287	325	371				
			12	178	204	234	270	311						12	208	233	264	299	341					
			13	183	211	244	282							13	212	240	274	312						
			14	188	218	253	295							14	217	248	283	325						
			15	192	225	263	307							15	222	255	293	337						
16	13	201	6		178	193	211	231	257	285	3/8″φ	2	13	6		212	227	245	265	291	319	1/2″φ	2 3/4	13
			7	170	185	203	223	247	277	310				7	204	219	236	257	281	311	344			
			8	174	192	212	236	263	297	335				8	208	226	246	270	297	331	369			
			9	179	199	222	248	279	317	360				9	213	233	256	282	313	351	394			
			10	184	206	231	261	295	338	385				10	218	240	265	295	329	372	419			
			11	189	213	241	273	311	358					11	223	247	275	307	345	392				
			12	194	220	251	286	327	378					12	228	254	285	320	361	412				
			13	199	227	260	299	343						13	233	261	294	333	377					
			14	204	234	270	311							14	238	268	304	345						
			15	209	241	280	324							15	243	275	313	358						
17	14	227	6		195	210	228	249	274	303	3/8″φ	2	14	6		233	249	266	287	313	341	1/2″φ	2 3/4	14
			7		202	220	241	265	294	328				7		240	258	279	303	333	366			
			8	192	209	230	253	281	315	353				8	230	248	268	292	319	353	391			
			9	197	216	239	266	297	335	378				9	235	255	278	304	335	373	416			
			10	202	223	249	278	313	355	403				10	240	262	287	317	351	394	441			
			11	207	230	259	291	329	375	428				11	245	269	297	329	367	414	466			
			12	212	238	268	304	345	396					12	250	276	306	342	383	434				
			13	217	245	278	316	361	416					13	255	283	316	354	399	454				
			14	221	252	287	329	377						14	260	290	326	367	415					
			15	226	259	297	341							15	265	297	335	380						
			16	231	266	307	354							16	270	304	345	392						
			17	236	273	316	366							17	274	311	355	405						
18	15	254	6		214	229	247	267	293	321	3/8″φ	2	15	6		257	272	290	310	336	364	1/2″φ	2 3/4	15
			7		221	239	259	283	313	346				7		264	282	302	326	356	389			
			8		228	248	272	299	333	371				8		271	291	315	342	376	414			
			9	215	235	258	284	315	354	396				9	258	278	301	327	358	396	439			
			10	220	242	267	297	331	374	421				10	263	285	310	340	374	417	464			
			11	225	249	277	310	347	394	446				11	268	292	320	352	390	437	489			
			12	230	256	287	322	363	414	471				12	273	299	330	365	406	457	514			
			13	235	263	296	335	379	435					13	278	306	339	378	422	477				
			14	240	270	306	347	395						14	283	313	349	390	438					
			15	245	277	316	360	411						15	288	320	359	403	454					
			16	250	284	325	372							16	293	327	368	415						
			17	255	291	335	385							17	298	334	378	428						

Loads to left of line ---- for Pg = .01 to .04
Loads between lines ---- and —— for Pg = .04 to .06
Loads to right of line —— for Pg = .06 to .08

Maximum number of vertical bars limited by allowable spacing of bars within the periphery of the column core.

REINFORCED CONCRETE COLUMNS

WITH SPIRALS

A. C. I. SPECIFICATION — 1941

$P = Ag(0.225\, f'c + fs\, Pg)$
$Ag = \pi D^2/4 \qquad Pg = As/Ag.$
fs = 16000 p.s.i.

P′ = Ratio volume spiral reinf. to volume concrete core.
Min. P′ = 0.45 (Ag/Ac — 1) f′c/f′s
or Min. P′ = 0.0112
f′s = 40,000 p.s.i.

ALLOWABLE AXIAL LOAD — KIPS

COLUMN SIZE D	CORE DIAM.	GROSS AREA AG.	f′c = 2000											f′c = 2500										
			No. VERT. BARS	⅝ φ	¾ φ	⅞ φ	1″ φ	1″ □	1⅛ □	1¼ □	SPIRAL			No. VERT. BARS	⅝ φ	¾ φ	⅞ φ	1″ φ	1″ □	1⅛ □	1¼ □	SPIRAL		
											BAR	PITCH	DIAM.									BAR	PITCH	DIAM.
19	16	284	6			185	202	223	249	277	⅜″φ	2½	16	6			217	234	255	280	309	⅜″φ	2¼	16
			7		177	194	215	239	269	302				7		208	226	247	271	301	334			
			8		184	204	228	255	289	327				8		216	236	260	287	321	359			
			9		191	214	240	271	309	352				9		223	246	272	303	341	384			
			10	176	198	223	253	287	330	377				10	208	230	255	285	319	361	409			
			11	181	205	233	265	303	350	402				11	213	237	265	297	335	382	434			
			12	186	212	243	278	319	370	427				12	218	244	274	310	351	402	459			
			13	191	219	252	290	335	390	452				13	223	251	284	322	367	422	484			
			14	196	226	262	303	351	411					14	228	258	294	335	383	442				
			15	201	233	271	316	367						15	233	265	303	347	399					
			16	206	240	281	328	383						16	238	272	313	360	415					
			17	211	247	291	341							17	242	279	323	373						
20	17	314	6			199	216	237	262	291	⅜″φ	2¼	17	6			234	252	273	298	326	⅜″φ	2¼	17
			7			208	229	253	283	316				7			244	264	288	318	351			
			8		197	218	241	269	303	341				8		233	253	277	304	338	376			
			9		204	227	254	285	323	366				9		240	263	289	320	358	401			
			10		212	237	267	301	343	391				10		247	272	302	336	379	426			
			11	195	219	247	279	317	364	416				11	230	254	282	314	352	399	451			
			12	200	226	256	292	333	384	441				12	235	261	292	327	368	419	476			
			13	205	233	266	304	349	404	466				13	240	268	301	340	384	439	501			
			14	210	240	276	317	365	424	491				14	245	275	311	352	400	460	526			
			15	215	247	285	329	381	445					15	249	282	321	365	416	480				
			16	219	254	295	342	397						16	254	289	330	377	432					
			17	224	261	304	355	413						17	259	296	340	390	448					
22	19	380	6				246	267	292	321	⅜″φ	2	19	6				289	309	335	363	⅜″φ	2	19
			7			238	259	283	312	346				7			281	301	325	355	388			
			8			248	271	299	333	371				8			290	314	341	375	413			
			9		234	257	284	315	353	396				9		277	300	326	357	396	438			
			10		241	267	296	331	373	421				10		284	310	339	373	416	463			
			11		248	276	309	347	393	446				11		291	319	352	389	436	488			
			12		255	286	321	363	414	471				12		298	329	364	405	456	513			
			13	234	262	296	334	379	434	496				13	277	305	338	377	421	477	538			
			14	239	270	305	346	395	454	521				14	282	312	348	389	437	497	563			
			15	244	277	315	359	411	474	546				15	287	319	358	402	453	517	588			
			16	249	284	324	372	427	495					16	292	326	367	414	469	537				
			17	254	291	334	384	443	515					17	297	333	377	427	485	558				
			18	259	298	344	397	459						18	302	341	387	440	501					
			19	264	305	353	409	475						19	307	348	396	452	517					
24	21	452	6				278	299	325	353	½″φ	3	21	6				329	350	375	404	½″φ	3	21
			7				291	315	345	378				7				342	366	396	429			
			8			280	304	331	365	403				8			331	355	382	416	454			
			9			290	316	347	385	428				9			341	367	398	436	479			
			10			299	329	363	406	453				10			350	380	414	456	504			
			11		281	309	341	379	426	478				11		332	360	392	430	477	529			
			12		288	319	354	395	446	503				12		339	369	405	446	497	554			
			13		295	328	366	411	466	528				13		346	379	417	462	517	579			
			14		302	338	379	427	487	553				14		353	389	430	478	537	604			
			15	277	309	347	392	443	507	578				15	328	360	398	442	494	558	629			
			16	282	316	357	404	459	527	603				16	333	367	408	455	510	578	654			
			17	287	323	367	417	475	547	628				17	337	374	418	468	526	598	679			
			18	291	330	376	429	491	568					18	342	381	427	480	542	618				
			19	296	337	386	442	507	588					19	347	388	437	493	558	639				
			20	301	344	395	454	523						20	352	395	446	505	574					
			21	306	352	405	467	539						21	357	402	456	518	590					

Loads to left of line ---- for Pg = .01 to .04
Loads between lines ---- and —— for Pg = .04 to .06
Loads to right of line —— for Pg = .06 to .08

Maximum number of vertical bars limited by allowable spacing of bars within the periphery of the column core.

REINFORCED CONCRETE COLUMNS

WITH SPIRALS

A. C. I. SPECIFICATION — 1941

$P = A_g(0.225 f'_c + f_s P_g)$
$A_g = \pi D^2/4$ $P_g = A_s/A_g$.
$f_s = 16000$ p.s.i.

$P' =$ Ratio volume spiral reinf. to volume concrete core.
Min. $P' = 0.45 (A_g/A_c - 1) f'_c/f'_s$
or Min. $P' = 0.0112$
$f'_s = 40{,}000$ p.s.i.

ALLOWABLE AXIAL LOAD — KIPS

COLUMN SIZE D	CORE DIAM.	GROSS AREA AG.	f'c = 3000 No. VERT. BARS	⅝ φ	¾ φ	⅞ φ	1″ φ	1″ □	1⅛ □	1¼ □	SPIRAL BAR	SPIRAL PITCH	SPIRAL DIAM.	f'c = 3750 No. VERT. BARS	⅝ φ	¾ φ	⅞ φ	1″ φ	1″ □	1⅛ □	1¼ □	SPIRAL BAR	SPIRAL PITCH	SPIRAL DIAM.
19	16	284	6			249	266	287	312	341	⅜″φ	2	16	6			296	314	335	360	389	½″φ	2¾	16
			7		240	258	279	303	333	366				7		288	306	327	351	380	414			
			8		247	268	291	319	353	391				8		295	316	339	367	401	439			
			9		254	277	304	335	373	416				9		302	325	352	383	421	464			
			10	240	262	287	317	351	393	441				10	288	309	335	364	399	441	489			
			11	245	269	297	329	367	414	466				11	293	316	345	377	415	461	514			
			12	250	276	306	342	383	434	491				12	298	324	354	390	431	482	539			
			13	255	283	316	354	399	454	516				13	303	331	364	402	447	502	564			
			14	260	290	326	367	415	474					14	307	338	373	415	463	522				
			15	265	297	335	379	431						15	312	345	383	427	479					
			16	269	304	345	392	447						16	317	352	393	440	495					
			17	274	311	354	404							17	322	359	402	452						
20	17	314	6			269	287	308	333	362	⅜″φ	2	17	6			322	340	361	386	415	½″φ	2¾	17
			7			279	300	324	353	387				7			332	353	377	406	440			
			8		268	289	312	340	374	412				8		321	342	365	393	427	465			
			9		275	298	325	356	394	437				9		328	351	378	409	447	490			
			10		282	308	337	372	414	462				10		335	361	390	425	467	515			
			11	266	289	317	350	388	434	487				11	319	342	370	403	441	487	540			
			12	270	296	327	362	404	455	512				12	323	349	380	415	457	508	565			
			13	275	303	337	375	420	475	537				13	328	356	390	428	473	528	590			
			14	280	311	346	387	436	495	562				14	333	364	399	441	489	548	615			
			15	285	318	356	400	452	515					15	338	371	409	453	505	568				
			16	290	325	366	413	468						16	343	378	419	466	521					
			17	295	332	375	425	484						17	348	385	428	478	537					
22	19	380	6				331	352	378	406	⅜″φ	2	19	6				396	416	442	470	½″φ	2¾	19
			7			323	344	368	398	431				7			388	408	432	462	495			
			8			333	357	384	418	456				8			397	421	448	482	520			
			9		320	343	369	400	438	481				9		384	407	433	464	502	545			
			10		327	352	382	416	459	506				10		391	416	446	480	523	570			
			11		334	362	394	432	479	531				11		398	426	458	496	543	595			
			12		341	372	407	448	499	556				12		405	436	471	512	563	620			
			13	320	348	381	419	464	519	581				13	384	412	445	484	528	583	645			
			14	325	355	391	432	480	540	606				14	389	419	455	496	544	604	670			
			15	330	362	400	445	496	560	631				15	394	426	465	509	560	624	695			
			16	335	369	410	457	512	580					16	399	433	474	521	576	644				
			17	340	376	420	470	528	600					17	404	440	484	534	592	664				
			18	344	383	429	482	544						18	409	447	493	546	608					
			19	349	390	439	495	560						19	414	455	503	559	624					
24	21	452	6				380	401	426	455	½″φ	3	21	6				457	477	503	531	½″φ	2¾	21
			7				393	417	447	480				7				469	493	523	556			
			8			382	405	433	467	505				8			458	482	509	543	581			
			9			391	418	449	487	530				9			468	494	525	563	606			
			10			401	431	465	507	555				10			477	507	541	584	631			
			11		383	411	443	481	528	580				11		459	487	519	557	604	656			
			12		390	420	456	497	548	605				12		466	497	532	573	624	681			
			13		397	430	468	513	568	630				13		473	506	545	589	644	706			
			14		404	440	481	529	588	655				14		480	516	557	605	665	731			
			15	379	411	449	493	545	609	680				15	455	487	526	570	621	685	756			
			16	383	418	459	506	561	629	705				16	460	494	535	582	637	705	781			
			17	388	425	468	518	577	649	730				17	465	501	545	595	653	725	806			
			18	393	432	478	531	593	669					18	470	508	554	607	669	746				
			19	398	439	488	544	609	690					19	474	516	564	620	685	766				
			20	403	446	497	556	625						20	479	523	574	633	701					
			21	408	453	507	569	641						21	484	530	583	645	717					

Loads to left of line ---- for $P_g = .01$ to $.04$
Loads between lines ---- and —— for $P_g = .04$ to $.06$
Loads to right of line —— for $P_g = .06$ to $.08$

Maximum number of vertical bars limited by allowable spacing of bars within the periphery of the column core.

REINFORCED CONCRETE COLUMNS

WITH SPIRALS

A. C. I. SPECIFICATION — 1941

$P = Ag(0.225\ f'c + fs\ Pg)$

$Ag = \pi D^2/4 \qquad Pg = As/Ag.$

$fs = 16000$ p.s.i.

P′ = Ratio volume spiral reinf. to volume concrete core.

Min. $P' = 0.45\ (Ag/Ac - 1)\ f'c/f's$

or Min. $P' = 0.0112$

$f's = 40{,}000$ p.s.i.

COLUMN SIZE D	CORE DIAM.	GROSS AREA AG.	ALLOWABLE AXIAL LOAD — KIPS																					
			f′c = 2000											f′c = 2500										
			No. VERT. BARS	⅝ φ	¾ φ	⅞ φ	1″ φ	1″ □	1⅛ □	1¼ □	SPIRAL			No. VERT. BARS	⅝ φ	¾ φ	⅞ φ	1″ φ	1″ □	1⅛ □	1¼ □	SPIRAL		
											BAR	PITCH	DIAM.									BAR	PITCH	DIAM.
26	23	531	6					334	360	388	½″φ	3	23	6					394	420	448	½″φ	3	23
			7				326	350	380	413				7				386	410	440	473			
			8				339	366	400	438				8				399	426	460	498			
			9			325	352	382	421	463				9			385	411	442	480	523			
			10			335	364	398	441	488				10			394	424	458	501	548			
			11			344	377	414	461	513				11			404	436	474	521	573			
			12			354	389	430	481	538				12			414	449	490	541	598			
			13		330	363	402	446	502	563				13		390	423	462	506	561	623			
			14		337	373	414	462	522	588				14		397	433	474	522	582	648			
			15		344	383	427	478	542	613				15		404	442	487	538	602	673			
			16		352	392	439	494	562	638				16		411	452	499	554	622	698			
			17		359	402	452	510	583	663				17		418	462	512	570	642	723			
			18	327	366	412	465	526	603	688				18	387	425	471	524	586	663	748			
			19	332	373	421	477	542	623	713				19	391	432	481	537	602	683	773			
			20	337	380	431	490	558	643					20	396	440	491	549	618	703				
			21	342	387	440	502	574	664					21	401	447	500	562	634	723				
28	25	616	6						398	427	½″φ	2¾	25	6						467	496	½″φ	2¾	25
			7					389	418	452				7					458	488	521			
			8				377	405	439	477				8				446	474	508	546			
			9				390	421	459	502				9				459	490	528	571			
			10				402	437	479	527				10				472	506	548	596			
			11			382	415	453	499	552				11			452	484	522	569	621			
			12			392	427	469	520	577				12			461	497	538	589	646			
			13			402	440	485	540	602				13			471	509	554	609	671			
			14		376	411	453	501	560	627				14		445	481	522	570	629	696			
			15		383	421	465	517	580	652				15		452	490	534	586	650	721			
			16		390	431	478	533	601	677				16		459	500	547	602	670	746			
			17		397	440	490	549	621	702				17		466	509	559	618	690	771			
			18		404	450	503	565	641	727				18		473	519	572	634	710	796			
			19		411	459	515	581	661	752				19		480	529	585	650	731	821			
			20	375	418	469	528	597	682	777				20	444	487	538	597	666	751	846			
			21	380	425	479	540	613	702					21	449	494	548	610	682	771				
			22	385	432	488	553	629	722					22	454	501	558	622	698	791				
			23	389	439	498	566	645	742					23	459	508	567	635	714	812				
30	27	707	6						439	468	½″φ	2½	27	6						519	547	½″φ	2½	27
			7					430	459	493				7					509	539	572			
			8					446	480	518				8					525	559	597			
			9				431	462	500	543				9				510	541	579	622			
			10				443	478	520	568				10				523	557	600	647			
			11				456	494	540	593				11				535	573	620	672			
			12			433	468	510	561	618				12			513	548	589	640	697			
			13			443	481	526	581	643				13			522	560	605	660	722			
			14			452	494	542	601	668				14			532	573	621	681	747			
			15			462	506	558	621	693				15			541	586	637	701	772			
			16		431	472	519	574	642	718				16		510	551	598	653	721	797			
			17		438	481	531	590	662	743				17		517	561	611	669	741	822			
			18		445	491	544	606	682	768				18		524	570	623	685	762	847			
			19		452	500	556	622	702	793				19		531	580	636	701	782	872			
			20		459	510	569	638	723	818				20		538	590	648	717	802	897			
			21		466	520	581	654	743	843				21		546	599	661	733	822	922			
			22		473	529	594	670	763	868				22		553	609	674	749	843	947			
			23	430	480	539	607	686	783					23	510	560	618	686	765	863				
			24	435	487	548	619	702	804					24	515	567	628	699	781	883				
			25	440	494	558	632	718	824					25	520	574	638	711	797	903				

Loads to left of line ---- for Pg = .01 to .04
Loads between lines ---- and —— for Pg = .04 to .06
Loads to right of line —— for Pg = .06 to .08

Maximum number of vertical bars limited by allowable spacing of bars within the periphery of the column core.

REINFORCED CONCRETE COLUMNS

WITH SPIRALS

A. C. I. SPECIFICATION — 1941

$P = Ag(0.225\, f'c + fs\, Pg)$
$Ag = \pi D^2/4 \quad Pg = As/Ag.$
16000 p.s.i.

P' = Ratio volume spiral reinf. to volume concrete core.
Min. $P' = 0.45\,(Ag/Ac - 1)\, f'c/f's$
or Min. $P' = 0.0112$
$f's = 40{,}000$ p.s.i.

ALLOWABLE AXIAL LOAD — KIPS

COLUMN SIZE D	CORE DIAM.	GROSS AREA AG.	f′c = 3000											f′c = 3750										
			No. VERT. BARS	⅝ φ	¾ φ	⅞ φ	1″ φ	1″ □	1⅛ □	1¼ □	SPIRAL			No. VERT. BARS	⅝ φ	¾ φ	⅞ φ	1″ φ	1″ □	1⅛ □	1¼ □	SPIRAL		
											BAR	PITCH	DIAM.									BAR	PITCH	DIAM.
26	23	531	6					454	479	508	½″φ	3	23	6					543	569	597	½″φ	2¾	23
			7				446	470	500	533				7				535	559	589	622			
			8				458	486	520	558				8				548	575	609	647			
			9			444	471	502	540	583				9			534	561	591	630	672			
			10			454	484	518	560	608				10			544	573	607	650	697			
			11			464	496	534	581	633				11			553	586	623	670	722			
			12			473	509	550	601	658				12			563	598	639	690	747			
			13		450	483	521	566	621	683				13		539	573	611	655	711	772			
			14		457	493	534	582	641	708				14		546	582	623	671	731	797			
			15		464	502	546	598	662	733				15		554	592	636	687	751	822			
			16		471	512	559	614	682	758				16		561	601	649	703	771	847			
			17		478	521	572	630	702	783				17		568	611	661	719	792	872			
			18	446	485	531	584	646	722	808				18	536	575	621	674	735	812	897			
			19	451	492	541	597	662	743	833				19	541	582	630	686	751	832	922			
			20	456	499	550	609	678	763					20	546	589	640	699	767	852				
			21	461	506	560	622	694	783					21	551	596	650	711	783	873				
28	25	616	6						537	565	½″φ	2¾	25	6						641	669	½″φ	2¾	25
			7					527	557	590				7					631	661	694			
			8				516	543	577	615				8				620	647	681	719			
			9				528	559	597	640				9				632	663	701	744			
			10				541	575	618	665				10				645	679	722	769			
			11			521	553	591	638	690				11			625	657	695	742	794			
			12			531	566	607	658	715				12			634	670	711	762	819			
			13			540	578	623	678	740				13			644	682	727	782	844			
			14		514	550	591	639	699	765				14		618	654	695	743	803	869			
			15		521	559	604	655	719	790				15		625	663	708	759	823	894			
			16		528	569	616	671	739	815				16		632	673	720	775	843	919			
			17		535	579	629	687	759	840				17		639	683	733	791	863	944			
			18		542	588	641	703	780	865				18		646	692	745	807	884	969			
			19		549	598	654	719	800	890				19		653	702	758	823	904	994			
			20	513	556	608	666	735	820	915				20	617	660	711	770	839	924	1019			
			21	518	564	617	679	751	840					21	622	667	721	783	855	944				
			22	523	571	627	692	767	861					22	627	675	731	795	871	965				
			23	528	578	636	704	783	881					23	632	682	740	808	887	985				
30	27	707	6						598	627	½″φ	2½	27	6						717	746	½″φ	2½	27
			7					589	618	652				7					708	738	771			
			8					605	639	677				8					724	758	796			
			9				590	621	659	702				9				709	740	778	821			
			10				602	637	679	727				10				722	756	798	846			
			11				615	653	699	752				11				734	772	819	871			
			12			592	627	669	720	777				12			711	747	788	839	896			
			13			602	640	685	740	802				13			721	759	804	859	921			
			14			611	653	701	760	827				14			731	772	820	879	946			
			15			621	665	717	780	852				15			740	784	836	900	971			
			16		590	631	678	733	801	877				16		709	750	797	852	920	996			
			17		597	640	690	749	821	902				17		716	759	810	868	940	1021			
			18		604	650	703	765	841	927				18		723	769	822	884	960	1046			
			19		611	659	715	781	861	952				19		730	779	835	900	981	1071			
			20		618	669	728	797	882	977				20		737	788	847	916	1001	1096			
			21		625	679	741	813	902	1002				21		744	798	860	932	1021	1121			
			22		632	688	753	829	922	1027				22		751	808	872	948	1041	1146			
			23	590	639	698	766	845	942					23	709	758	817	885	964	1062				
			24	594	646	708	778	861	963					24	714	766	827	897	980	1082				
			25	599	653	717	791	877	983					25	719	773	836	910	996	1102				

Loads to left of line ---- for Pg = .01 to .04
Loads between lines ---- and —— for Pg = .04 to .06
Loads to right of line —— for Pg = .06 to .08

Maximum number of vertical bars limited by allowable spacing of bars within the periphery of the column core.

COLUMN SPIRALS

PERCENTAGE OF CORE

SIZE ROD	PITCH	COLUMN CORE DIAMETER, IN INCHES																														
		10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
¼ φ	1½	1.31	1.19	1.09	1.01	.93	.87	.82	.77	.73	.69	.66	.62	.59	.57	.55	.52	.50	.49	.47												
	1¾	1.12	1.02	.94	.86	.80	.75	.70	.66	.62	.59	.56	.53	.51	.49	.47	.45	.43														
	2	.98	.89	.82	.76	.70	.65	.61	.58	.55	.52	.49	.47	.45																		
	2¼	.87	.79	.73	.67	.62	.58	.55	.51	.49	.46																					
	2½	.79	.71	.66	.61	.56	.52	.49	.46																							
	2¾	.72	.65	.59	.55	.51	.48																									
	3	.66	.60	.55	.50	.47																										
5/16 φ	1½	2.05	1.86	1.70	1.57	1.46	1.36	1.28	1.20	1.14	1.08	1.02	.97	.93	.89	.85	.82	.79	.76	.73	.71	.68	.66	.64	.62	.60	.59	.57	.55	.54	.53	.51
	1¾	1.75	1.59	1.46	1.35	1.25	1.17	1.10	1.03	.98	.92	.88	.83	.80	.76	.73	.70	.68	.65	.63	.61	.58	.57	.55	.53	.52	.50	.49	.47	.46	.45	.44
	2	1.53	1.39	1.28	1.18	1.10	1.02	.96	.90	.85	.81	.77	.73	.70	.67	.64	.61	.59	.57	.55	.53	.51	.50	.48	.47	.45	.44					
	2¼	1.36	1.24	1.14	1.05	.97	.91	.85	.80	.76	.72	.68	.65	.62	.59	.57	.55	.53	.51	.49	.47	.46										
	2½	1.23	1.12	1.02	.94	.88	.82	.77	.72	.68	.65	.61	.58	.56	.53	.51	.49	.47	.45													
	2¾	1.12	1.01	.93	.86	.80	.74	.70	.66	.62	.59	.56	.53	.51	.49	.47	.45															
	3	1.02	.93	.85	.79	.73	.68	.64	.60	.57	.54	.51	.49	.47																		
⅜ φ	1½				2.27	2.11	1.96	1.84	1.73	1.64	1.55	1.47	1.40	1.34	1.28	1.23	1.18	1.13	1.09	1.05	1.02	.98	.95	.92	.89	.87	.84	.82	.80	.78	.76	.74
	1¾			2.11	1.94	1.80	1.68	1.58	1.49	1.40	1.33	1.26	1.20	1.15	1.10	1.05	1.01	.97	.94	.90	.87	.84	.82	.79	.77	.74	.72	.70	.68	.67	.65	.63
	2	2.21	2.01	1.84	1.70	1.58	1.47	1.38	1.30	1.23	1.16	1.11	1.05	1.01	.96	.92	.88	.85	.82	.79	.76	.74	.71	.69	.67	.65	.63	.61	.60	.58	.57	.55
	2¼	1.96	1.79	1.64	1.51	1.40	1.31	1.23	1.16	1.09	1.03	.98	.94	.89	.85	.82	.79	.76	.73	.70	.68	.66	.63	.61	.60	.58	.56	.55	.53	.52	.50	.49
	2½	1.77	1.61	1.48	1.36	1.26	1.18	1.11	1.04	.98	.93	.88	.84	.80	.77	.74	.71	.68	.66	.63	.61	.59	.57	.55	.54	.52	.51	.49	.48	.47	.45	
	2¾	1.61	1.46	1.34	1.24	1.15	1.07	1.00	.95	.89	.85	.80	.77	.73	.70	.67	.64	.62	.60	.57	.55	.54	.52	.50	.49	.47	.46					
	3	1.47	1.34	1.23	1.13	1.05	.98	.92	.87	.82	.78	.74	.70	.67	.64	.61	.59	.57	.55	.53	.51	.49	.48	.46								
½ φ	2									2.18	2.07	1.96	1.87	1.79	1.71	1.64	1.57	1.51	1.46	1.40	1.35	1.31	1.27	1.23	1.19	1.16	1.12	1.09	1.06	1.03	1.01	.98
	2¼							2.18	2.05	1.94	1.84	1.75	1.66	1.59	1.52	1.46	1.40	1.34	1.29	1.25	1.20	1.17	1.13	1.09	1.06	1.03	1.00	.97	.94	.92	.90	.87
	2½						2.10	1.96	1.85	1.75	1.65	1.57	1.50	1.43	1.37	1.31	1.26	1.21	1.16	1.12	1.08	1.05	1.01	.98	.95	.93	.90	.87	.85	.83	.81	.79
	2¾					2.04	1.90	1.79	1.68	1.59	1.50	1.43	1.36	1.30	1.24	1.19	1.14	1.10	1.06	1.02	.99	.95	.92	.89	.87	.84	.82	.79	.77	.75	.73	.72
	3				2.01	1.87	1.75	1.64	1.54	1.46	1.38	1.31	1.25	1.19	1.14	1.09	1.05	1.01	.97	.94	.90	.87	.85	.82	.79	.77	.75	.73	.71	.69	.67	.66
⅝ φ	2																			2.20	2.12	2.05	1.98	1.92	1.86	1.81	1.76	1.71	1.66	1.62	1.58	1.54
	2¼																2.18	2.10	2.02	1.95	1.88	1.82	1.76	1.71	1.66	1.61	1.56	1.52	1.48	1.44	1.40	1.36
	2½														2.14	2.05	1.97	1.89	1.82	1.76	1.70	1.64	1.59	1.54	1.49	1.45	1.41	1.37	1.33	1.29	1.26	1.23
	2¾												2.12	2.03	1.94	1.86	1.79	1.72	1.65	1.60	1.54	1.49	1.44	1.39	1.35	1.32	1.28	1.24	1.21	1.18	1.15	1.12
	3											2.04	1.95	1.86	1.78	1.71	1.64	1.58	1.52	1.46	1.41	1.36	1.32	1.28	1.24	1.21	1.17	1.14	1.11	1.08	1.05	1.02

Spacers—¼" Spiral—10" to 15" dia. 1.6 # per ft.
Spacers—¼" Spiral—16" to 30" dia. 2.0 # per ft.
Spacers—5/16" Spiral—10" to 15" dia. 2.0 # per ft.
Spacers—5/16" Spiral—16" to 30" dia. 3.0 # per ft.

WEIGHT PER FOOT OF HEIGHT

NOT INCLUDING SPACERS

Spacers—⅜" Spiral—10" to 15" dia. 2.0 # per ft.
Spacers—⅜" Spiral—16" to 30" dia. 3.0 # per ft.
Spacers—½" Spiral—10" to 30" dia. 3.0 # per ft.
Spacers—⅝" Spiral—10" to 30" dia. 3.0 # per ft.

SIZE ROD	PITCH	COLUMN CORE DIAMETER, IN INCHES																														
		10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
¼ φ	1½	3.5	3.9	4.2	4.5	4.9	5.2	5.6	5.9	6.3	6.6	7.0	7.3	7.7	8.1	8.4	8.8	9.1	9.5	9.8												
	1¾	3.0	3.3	3.6	3.9	4.2	4.5	4.8	5.1	5.4	5.7	6.0	6.3	6.6	6.9	7.2	7.5	7.8														
	2	2.6	2.9	3.2	3.4	3.7	3.9	4.2	4.5	4.7	5.0	5.3	5.5	5.8																		
	2¼	2.3	2.6	2.8	3.0	3.3	3.5	3.7	4.0	4.2	4.4																					
	2½	2.1	2.3	2.5	2.7	2.9	3.2	3.4																								
	2¾	1.9	2.1	2.3	2.5	2.7	2.9																									
	3	1.8	1.9	2.1	2.3	2.5																										
5/16 φ	1½	5.5	6.0	6.6	7.1	7.7	8.2	8.8	9.3	9.9	10.4	10.9	11.5	12.0	12.6	13.1	13.7	14.2	14.8	15.3	15.9	16.4	17.0	17.5	18.1	18.6	19.2	19.7	20.2	20.8	21.3	21.9
	1¾	4.7	5.2	5.6	6.1	6.6	7.0	7.5	8.0	8.5	8.9	9.4	9.9	10.3	10.8	11.3	11.7	12.2	12.7	13.1	13.6	14.1	14.5	15.0	15.5	15.9	16.4	16.9	17.4	17.8	18.3	18.8
	2	4.1	4.5	4.9	5.3	5.8	6.2	6.6	7.0	7.4	7.8	8.2	8.6	9.0	9.4	9.9	10.3	10.7	11.1	11.5	11.9	12.3	12.7	13.1	13.5	14.0	14.4					
	2¼	3.7	4.0	4.4	4.7	5.1	5.5	5.8	6.2	6.6	6.9	7.3	7.7	8.0	8.4	8.8	9.1	9.5	9.9	10.2	10.6	10.9										
	2½	3.3	3.6	3.9	4.3	4.6	4.9	5.3	5.6	5.9	6.2	6.6	6.9	7.2	7.6	7.9	8.2	8.5	8.9													
	2¾	3.0	3.3	3.6	3.9	4.2	4.5	4.8	5.1	5.4	5.7	6.0	6.3	6.6	6.9	7.2	7.5															
	3	2.7	3.0	3.3	3.6	3.8	4.1	4.4	4.7	4.9	5.2	5.5	5.8	6.0																		
⅜ φ	1½						11.8	12.6	13.4	14.2	14.9	15.7	16.5	17.3	18.1	18.9	19.7	20.4	21.2	22.0	22.8	23.6	24.4	25.2	26.0	26.8	27.5	28.3	29.1	29.9	30.7	31.5
	1¾						10.1	10.8	11.5	12.1	12.8	13.5	14.2	14.8	15.5	16.2	16.9	17.5	18.2	18.9	19.6	20.2	20.9	21.6	22.3	23.0	23.6	24.3	25.0	25.6	26.3	27.0
	2						8.9	9.4	10.0	10.6	11.2	11.8	12.4	13.0	13.6	14.2	14.7	15.4	15.9	16.5	17.1	17.7	18.3	18.9	19.5	20.1	20.7	21.3	21.9	22.4	23.0	23.7
	2¼						7.9	8.4	8.9	9.4	10.0	10.5	11.0	11.5	12.1	12.6	13.1	13.6	14.2	14.7	15.2	15.7	16.3	16.8	17.3	17.8	18.4	18.9	19.4	19.9	20.5	21.0
	2½						7.1	7.6	8.0	8.5	9.0	9.4	9.9	10.4	10.9	11.3	11.8	12.3	12.7	13.2	13.7	14.2	14.6	15.1	15.6	16.1	16.5	17.0	17.5	18.0	18.4	
	2¾						6.4	6.9	7.3	7.7	8.2	8.6	9.0	9.5	9.9	10.3	10.7	11.2	11.6	12.0	12.5	12.9	13.3	13.7	14.2	14.6	15.0					
	3						5.9	6.3	6.7	7.1	7.5	7.9	8.3	8.7	9.1	9.5	9.8	10.2	10.6	11.0	11.4	11.8	12.2	12.6								
½ φ	2									18.9	20.0	21.0	22.0	23.1	24.1	25.2	26.2	27.2	28.3	29.4	30.4	31.5	32.5	33.6	34.6	35.6	36.7	37.8	38.8	39.9	40.9	42.0
	2¼							14.9	15.9	16.8	17.7	18.6	19.6	20.5	21.4	22.4	23.3	24.3	25.2	26.1	27.1	28.0	28.9	29.8	30.8	31.7	32.6	33.6	34.5	35.5	36.4	37.4
	2½						12.6	13.4	14.3	15.1	16.0	16.8	17.6	18.5	19.3	20.2	21.0	21.8	22.7	23.5	24.4	25.2	26.0	26.8	27.7	28.5	29.4	30.2	31.1	31.9	32.8	33.6
	2¾					10.7	11.4	12.2	13.0	13.7	14.5	15.3	16.0	16.8	17.6	18.3	19.1	19.9	20.6	21.4	22.2	22.9	23.6	24.4	25.2	25.9	26.7	27.5	28.2	29.1	29.7	30.6
	3				9.1	9.8	10.5	11.2	11.9	12.6	13.3	14.0	14.7	15.4	16.1	16.8	17.5	18.2	18.9	19.6	20.3	21.0	21.7	22.4	23.1	23.8	24.5	25.2	25.9	26.6	27.3	28.0
⅝ φ	2																			46.8	48.4	49.3	50.9	52.6	54.2	55.9	57.5	59.2	60.8	62.4	64.1	65.8
	2¼																37.2	38.7	40.2	41.8	43.1	43.8	45.3	46.7	48.2	49.7	51.2	52.6	54.1	55.5	56.9	58.4
	2½														30.8	32.2	33.5	34.8	36.2	37.5	38.8	39.4	40.8	42.2	43.3	44.7	46.1	47.4	48.6	49.8	51.2	52.6
	2¾												25.6	26.8	28.0	29.3	30.5	31.7	32.8	34.1	35.2	35.8	37.0	38.2	39.4	40.6	41.8	42.9	44.2	45.3	46.6	47.8
	3											22.4	23.5	24.6	25.7	26.8	28.0	29.1	30.2	31.3	32.4	32.8	33.9	35.1	36.1	37.3	38.3	39.4	40.5	41.6	42.7	43.8

EXPLANATION OF UNIVERSAL FOOTING TABLES

By the use of the Universal Footing Tables the design of square column footings is greatly simplified. Slab, stepped or sloping top footings may be designed alike, and for any possible degree of soil pressure variation. They are based upon recommendations of the Joint Committee.

DESIGN: TYPICAL SLAB FOOTING.

Suppose it is desired to transmit a column load of 350000 lbs. to a slab footing, with allowable soil pressure of 4000 lbs. sq. ft. Column 28″x28″.

Preliminary area required would be $350000 \div 4000 = 87.5$ sq. ft. or approximately 9′-4″ × 9′-4″, but to allow for the weight of the footing, consider the footing as say, 10′-0″ × 10′-0″. From the graph of footing weights on Page 72, entering at 10′-0″ on the lower edge and proceeding vertically, the intersection with 28″ column curve shows that 110.2% of the column load will represent the combined load of column and footing weight, or $110.2 \times 350000 = 386000$ lbs. The area of footing required will then be $386000 \div 4000 = 96.6$ sq. ft. with an actual size of 9′-10″ × 9′-10″.

Referring to the Universal Tables, under 28″ column on 9′-10″ footing, we find

$C_d = 14.24 \qquad A_s = 5.79$

Since $d = P \div C_d$, the required effective depth will be

$$d = \frac{350000}{14.24} = 24.6'', \text{ with } 5.79\square'' \text{ steel required for Moment, or } 29\ \tfrac{1}{2}\phi \text{ bars.}$$

If straight deformed bars are used, with allowable bond at 75 #/□″, the total Σ_0 of bars required will be found in table, under 28″ column, as 51.2□″, requiring 33 ½φ bars. This is 4 more than the number required for moment.

If hooked deformed bars are used, an allowable bond stress of 150 #/□″ is permitted for 2000 lb. concrete. For the depth used (determined by punching shear) with a column 28″ square, the tables show Σ_0 required of 25.6□″, or half that required for straight bars, and the number of bars will be $33 \div 2 = 17$.

Specifications require that when hooked bars are used their length must equal the width of the footing, plus 20 diameters, and that the outer face of the hook shall be not less than 3″, nor more than 4″, from edge of footing.

For some reason it might be desirable to deepen the footing, such as to reduce diagonal tension or bond stress or to reduce A_s. Assume an effective depth of 30″, instead of 24.6″ as found necessary for punching shear. The area of steel will then be

$$A_s = \frac{24.6}{30} \times 5.79 = 4.75\square'', \text{ requiring } 24\ \tfrac{1}{2}\phi \text{ bars.}$$

$$\text{The number required for bond: } \left(\frac{24.6}{30} \times 51.2\right) \div 1.57 = 27\ \tfrac{1}{2}\phi \text{ bars.}$$

In investigating for diagonal tension, an allowable value of 40 #/□″ is used for straight and 60 #/□″ for hooked deformed bars with 2000# concrete. The formula for diagonal tension is

$$v = \frac{K_1 P}{(c + 2d)\ jd}$$

In the example, with an effective depth of 24.6″, $c + 2d = 28 + (2 \times 24.6) = 77.2''$, say 77″. The accompanying tables of direct values of K_1 show, for $C + 2d$ of 77″ and l of 9′-10″, $K_1 = .143$.

$$\text{Then } v = \frac{.143 \times 350000}{77 \times .875 \times 24.6} = 30.2\ \#/\square''$$

STEPPED FOOTING.

For a column of same size and load as above the size and depth of footing will be the same, save for a negligible reduction in dead weight of footing.

The ratio c/l is $28/118 = .238$ and from the table this ratio requires a width of top block, "a", of $.45l$ or 53″, use 54″. The depth of the lower block should be $0.6d$ or $0.6 \times 24.6'' = 14.75''$.

The bending moment and bond at face of column will be as before. The bond at edge of top block must, however, be checked. For this, enter the tables for Σ_0 at $C = 54''$ (width top block) and find $\Sigma_0 = 98.6$ for straight and 49.3 for hooked bars, with number of bars required as given. If further reduction is necessary, the width of top block must be increased.

Diagonal tension must be computed in the lower block at point $c + 2d$ or 77″ for $d = 24.6''$. The lower block is 14.75″ deep and K_1 for the ratio of 77/118 is .143. Therefore

$$v = \frac{.143 \times 350000}{77 \times .875 \times 14.75} = 50.3\ \#/\square''.$$

This is satisfactory for hooked bars, but the lower block must be deepened if straight bars are used.

SLOPED FOOTING.

The design of a sloped top footing is similar to the foregoing except that "a", the width at top, for the ratio of $28 \div 118 = .238$ will be $.34l = 40''$. The depth of sloped footings at point where diagonal tension must be considered is at $c + 2d$ of 77″ as before, and may be found by equating $v = \dfrac{K_1 P}{(c + 2d)\ jd}$ *which gives* $d_1 = \dfrac{K_1 P}{(c + 2d)\ jd}$

or, in this case $d_1 = \dfrac{.143 \times 350000}{77 \times .875 \times 60} = 11.94''$ for hooked bars.

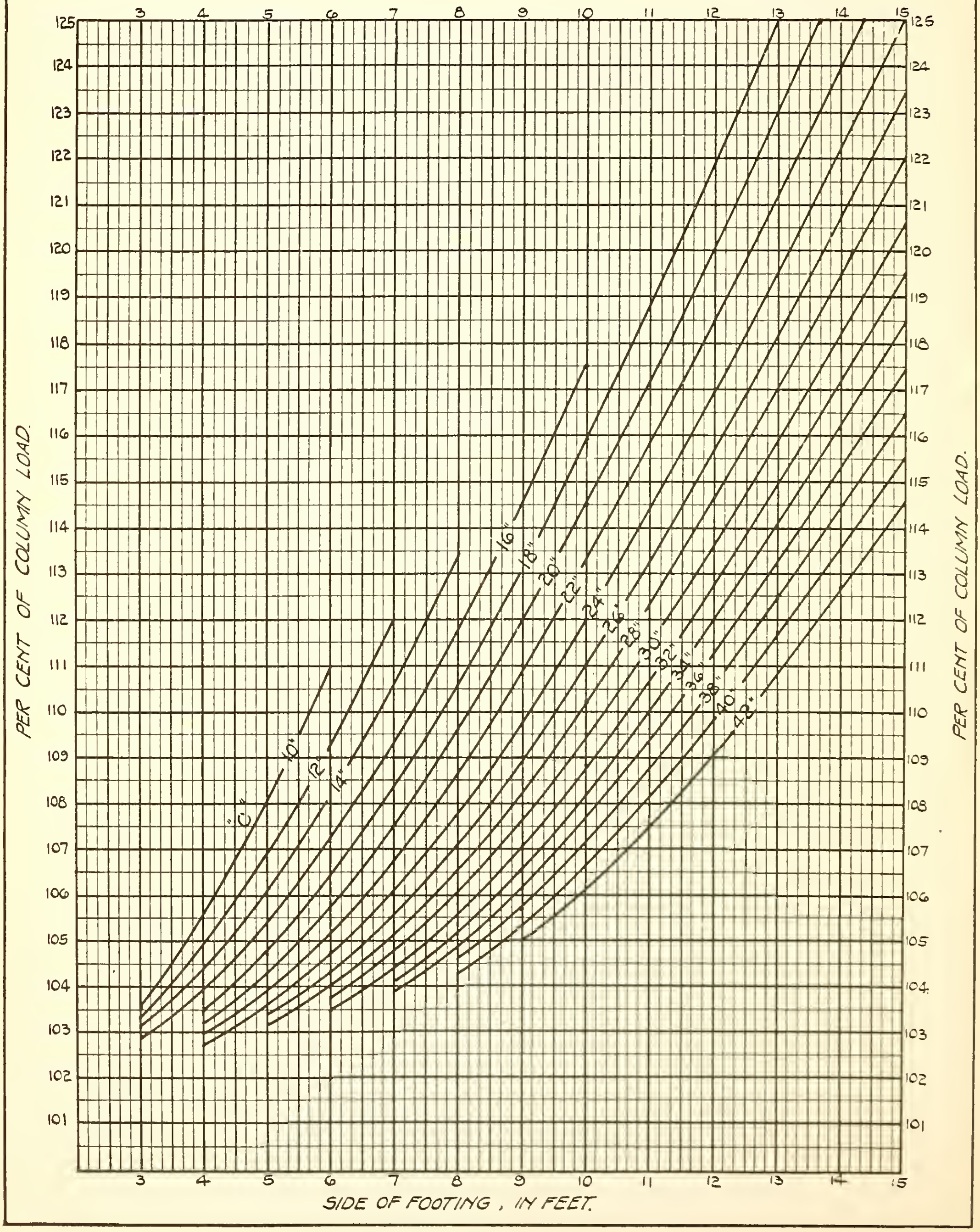
SQUARE SLAB COLUMN FOOTINGS

APPROXIMATE TOTAL WEIGHT OF FOOTING AND COLUMN LOAD IN TERMS OF PERCENT OF COLUMN LOAD

FOR DETERMINING FOOTING AREA

ANY SOIL PRESSURE

AREA = Column load multiplied by percentage given for proper column size, divided by soil pressure.



UNIVERSAL FOOTING TABLES

FOR SQUARE SLAB COLUMN FOOTINGS

P = Column load, in kips.
C_d = Constant for footing depth.
d = Effective depth = $\frac{P}{C_d}$
A_s = Area steel req'd for Moment, each way;
latter in inch lbs , for punching shear of 120 #/□″.

Add 4″ to Depth as Found by $\frac{P}{Cd}$

$F_s = 18{,}000$

SIDE OF SQUARE FOOTING	AREA SQ. FT.	CONST	SIZE SQUARE COLUMN, IN INCHES (C)																
			10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42
2′-6″	6.3	Cd	5.40	6.85	8.60	10.70	13.50												
		As	.45	.47	.48	.47	.45												
2′-8″	7.1	Cd	5.34	6.70	8.33	10.20	12.60												
		As	.50	.53	.55	.55	.53												
2′-10″	8.0	Cd	5.26	6.57	8.10	9.85	12.00	14.70											
		As	.55	.59	.62	.62	.62	.58											
3′-0″	9.0	Cd	5.20	6.48	7.93	9.57	11.47	13.86											
		As	.60	.65	.68	.70	.70	.67											
3′-2″	10.0	Cd	5.15	6.40	7.80	9.35	11.15	13.25	15.90										
		As	.65	.71	.75	.78	.79	.77	.73										
3′-4″	11.1	Cd	5.12	6.33	7.63	9.15	10.84	12.75	15.15										
		As	.70	.77	.82	.86	.87	.86	.83										
3′-6″	12.3	Cd	5.09	6.25	7.56	9.00	10.56	12.40	14.60	17.00									
		As	.75	.83	.89	.93	.96	.96	.93	.90									
3′-8″	13.4	Cd	5.06	6.21	7.50	8.85	10.37	12.10	14.05	16.40									
		As	.80	.89	.96	1.01	1.04	1.05	1.04	1.01									
3′-10″	14.7	Cd	5.04	6.17	7.43	8.72	10.20	11.80	13.70	15.85	18.30								
		As	.85	.95	1.02	1.09	1.13	1.14	1.14	1.12	1.08								
4′-0″	16.0	Cd	5.02	6.14	7.35	8.62	10.02	11.60	13.40	15.30	17.70								
		As	.90	1.01	1.09	1.16	1.21	1.24	1.24	1.23	1.20								
4′-2″	17.4	Cd	5.00	6.10	7.28	8.55	9.90	11.42	13.05	15.00	17.15	19.50							
		As	.95	1.07	1.16	1.24	1.30	1.33	1.35	1.35	1.32	1.29							
4′-4″	18.8	Cd	4.98	6.07	7.25	8.48	9.80	11.28	12.80	14.67	16.60	18.90							
		As	1.00	1.13	1.23	1.32	1.39	1.43	1.49	1.46	1.44	1.41							
4′-6″	20.3	Cd	4.97	6.05	7.22	8.44	9.70	11.10	12.65	14.33	16.30	18.40	20.80						
		As	1.05	1.19	1.30	1.39	1.47	1.52	1.55	1.57	1.56	1.54	1.50						
4′-8″	21.8	Cd	4.96	6.03	7.18	8.36	9.65	11.00	12.47	14.10	15.90	17.85	20.20						
		As	1.10	1.25	1.36	1.47	1.56	1.61	1.65	1.68	1.69	1.67	1.64						
4′-10″	23.4	Cd	4.95	6.01	7.14	8.32	9.59	10.90	12.23	13.90	15.60	17.50	19.75	22.00					
		As	1.15	1.31	1.43	1.55	1.64	1.71	1.76	1.80	1.81	1.80	1.78	1.73					
5′-0″	25.0	Cd	4.94	6.00	7.10	8.28	9.53	10.80	12.20	13.70	15.35	17.20	19.20	21.40					
		As	1.20	1.37	1.50	1.63	1.73	1.80	1.86	1.91	1.93	1.93	1.92	1.88					
5′-2″	26.7	Cd	4.94	5.98	7.08	8.24	9.38	10.72	12.07	13.55	15.13	16.95	18.80	20.90	23.40				
		As	1.25	1.43	1.57	1.70	1.81	1.90	1.96	2.02	2.05	2.06	2.05	2.02	2.00				
5′-4″	28.4	Cd	4.93	5.97	7.06	8.20	9.34	10.65	11.95	13.40	14.92	16.60	18.40	20.40	22.60				
		As	1.30	1.49	1.64	1.78	1.90	1.99	2.07	2.13	2.17	2.19	2.19	2.17	2.15				
5′-6″	30.3	Cd	4.92	5.96	7.04	8.17	9.31	10.57	11.87	13.26	14.76	16.40	18.25	20.00	22.20	24.60			
		As	1.35	1.55	1.70	1.86	1.98	2.08	2.17	2.25	2.29	2.32	2.33	2.31	2.30	2.26			
5′-8″	32.1	Cd	4.92	5.95	7.02	8.14	9.28	10.50	11.80	13.12	14.60	16.20	17.90	19.70	21.70	24.00			
		As	1.40	1.61	1.77	1.93	2.07	2.18	2.27	2.36	2.41	2.45	2.47	2.46	2.45	2.42			
5′-10″	34.0	Cd	4.91	5.93	7.00	8.11	9.25	10.44	11.73	13.03	14.45	16.02	17.65	19.45	21.35	23.50	25.80		
		As	1.45	1.67	1.84	2.01	2.16	2.27	2.38	2.47	2.53	2.58	2.61	2.61	2.60	2.59	2.54		
6′-0″	36.0	Cd	4.90	5.92	6.98	8.08	9.22	10.38	11.66	12.94	14.30	15.85	17.40	19.20	21.00	23.00	25.40	27.80	
		As	1.50	1.73	1.91	2.09	2.24	2.37	2.48	2.58	2.65	2.70	2.75	2.76	2.76	2.75	2.71	2.68	
6′-2″	38.0	Cd	4.90	5.91	6.97	8.06	9.19	10.34	11.59	12.87	14.21	15.67	17.20	18.95	20.70	22.60	24.80	27.20	
		As	1.55	1.79	1.98	2.16	2.33	2.46	2.58	2.70	2.77	2.83	2.89	2.90	2.92	2.91	2.89	2.86	
6′-4″	40.1	Cd	4.90	5.90	6.96	8.04	9.16	10.30	11.52	12.80	14.12	15.50	17.05	18.70	20.40	22.20	24.25	26.60	29.00
		As	1.60	1.85	2.04	2.24	2.41	2.55	2.68	2.81	2.90	2.96	3.02	3.04	3.07	3.07	3.06	3.04	2.98
6′-6″	42.3	Cd	4.89	5.90	6.95	8.02	9.13	10.28	11.46	12.75	14.04	15.40	16.90	18.50	20.15	21.90	23.95	26.00	28.50
		As	1.65	1.91	2.11	2.32	2.50	2.65	2.79	2.92	3.02	3.09	3.16	3.19	3.22	3.24	3.23	3.22	3.16
6′-8″	44.4	Cd	4.89	5.89	6.94	8.00	9.10	10.24	11.40	12.70	13.96	15.30	16.75	18.30	19.90	21.65	23.60	25.50	27.80
		As	1.70	1.97	2.18	2.40	2.58	2.74	2.89	3.03	3.14	3.22	3.30	3.34	3.37	3.40	3.41	3.39	3.35
6′-10″	46.7	Cd	4.88	5.88	6.93	7.98	9.08	10.20	11.35	12.65	13.88	15.20	16.60	18.15	19.70	21.40	23.25	25.20	27.30
		As	1.75	2.03	2.25	2.47	2.67	2.84	2.99	3.15	3.26	3.35	3.44	3.48	3.53	3.56	3.59	3.57	3.55

If hooked bars are used, use half the number of bars shown.

TOTAL PERIMETER BARS (Σ_0) REQ'D E. W. FOR BOND

Bond stress 75 #/□″ for straight def. bar.
Bond stress 150 #/□″ for hooked def. bar.

SIZE	PERIMETER 1 BAR	Σ_0 Given for Column Sizes Shown, for Both Straight and Hooked Bars. Number Given is for Straight Bars, E. W.																
		10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42
Σ_0 STRAIGHT =		18.4	22.0	25.6	29.3	33.0	36.6	40.3	43.9	47.6	51.2	54.9	58.5	62.2	65.8	69.5	73.1	76.8
Σ_0 HOOKED =		9.2	11.0	12.8	14.7	16.5	18.3	20.2	22.0	23.8	25.6	27.5	29.3	31.1	32.9	34.8	36.6	38.4
⅜φ	1.18	16	19	22	25	28	31	34	38	41	44	47	50	53	56	59	62	65
½φ	1.57	12	14	17	19	21	24	26	28	31	33	35	38	40	42	45	47	49
⅝φ	1.96	10	12	14	15	17	19	21	23	25	27	28	30	32	34	36	38	40
¾φ	2.36	8	10	11	13	14	16	17	19	21	22	24	25	27	28	30	31	33

AREAS OF RENIFORCING BARS

SIZE	AREA 1 BAR	WT. 1 BAR	AREAS OF VARIOUS NUMBERS OF BARS SHOWN																			
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
⅜φ	.11	.38	.11	.22	.33	.44	.55	.66	.77	.88	.99	1.10	1.21	1.32	1.43	1.54	1.65	1.76	1.87	1.98	2.09	2.20
½φ	.20	.68	.20	.39	.59	.78	.98	1.18	1.37	1.57	1.76	1.96	2.16	2.35	2.55	2.74	2.94	3.14	3.33	3.53	3.72	3.92
⅝φ	.31	1.06	.31	.61	.92	1.23	1.54	1.84	2.15	2.46	2.76	3.07	3.38	3.68	3.99	4.30	4.61	4.91	5.22	5.53	5.83	6.14
¾φ	.44	1.52	.44	.88	1.33	1.77	2.21	2.65	3.09	3.54	3.98	4.42	4.86	5.30	5.75	6.19	6.63	7.07	7.51	7.96	8.40	8.84

P = Column load, in kips.
C_d = Constant for footing depth.
d = Effective depth = $\frac{P}{C_d}$
A_s = Area steel req'd for Moment, each way;
latter in inch lbs., for punching shear of 120 ♯/□″.

UNIVERSAL FOOTING TABLES

FOR SQUARE SLAB COLUMN FOOTINGS

Add 4″ to Depth as Found by $\frac{P}{Cd}$

$F_s = 18{,}000$

SIDE OF SQUARE FOOTING	AREA SQ. FT.	CONST.	SIZE SQUARE COLUMN IN INCHES. (C)																		
			12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
7′-0″	49.0	Cd	5.88	6.91	7.97	9.06	10.16	11.31	12.57	13.80	15.10	16.50	17.90	19.50	21.20	22.95	24.85	26.80	29.20	31.60	
		As	2.06	2.31	2.55	2.75	2.93	3.10	3.26	3.38	3.48	3.58	3.63	3.68	3.72	3.75	3.75	3.71	3.70	3.65	
7′-2″	51.4	Cd	5.87	6.90	7.96	9.04	10.14	11.28	12.50	13.74	15.00	16.40	17.75	19.30	21.00	22.70	24.50	26.40	28.60	31.00	
		As	2.12	2.38	2.63	2.84	3.03	3.21	3.38	3.51	3.62	3.72	3.79	3.84	3.89	3.93	3.94	3.91	3.90	3.86	
7′-4″	53.8	Cd	5.87	6.89	7.95	9.02	10.12	11.25	12.45	13.66	14.92	16.30	17.65	19.15	20.80	22.45	24.20	26.10	28.10	30.40	32.90
		As	2.18	2.45	2.71	2.99	3.13	3.32	3.50	3.63	3.75	3.87	3.94	4.01	4.06	4.11	4.13	4.11	4.10	4.08	4.02
7′-6″	56.3	Cd	5.86	6.88	7.94	9.00	10.10	11.22	12.40	13.58	14.85	16.22	17.55	19.02	20.60	22.20	23.95	25.80	27.80	29.90	32.20
		As	2.24	2.52	2.79	3.02	3.23	3.43	3.62	3.76	3.89	4.01	4.10	4.17	4.23	4.29	4.31	4.30	4.30	4.29	4.24
7′-8″	58.8	Cd	5.86	6.88	7.93	8.98	10.08	11.19	12.35	13.52	14.78	16.13	17.48	18.90	20.45	22.00	23.65	25.50	27.40	29.30	31.80
		As	2.30	2.59	2.87	3.11	3.33	3.53	3.73	3.89	4.02	4.16	4.25	4.33	4.40	4.47	4.50	4.51	4.51	4.50	4.46
7′-10″	61.4	Cd	5.86	6.87	7.92	8.97	10.06	11.16	12.31	13.47	14.72	16.05	17.40	18.80	20.30	21.80	23.40	25.20	27.00	29.10	31.30
		As	2.36	2.66	2.95	3.20	3.43	3.64	3.85	4.01	4.16	4.30	4.41	4.50	4.58	4.65	4.69	4.70	4.72	4.72	4.68
8′-0″	64.0	Cd	5.85	6.87	7.91	8.96	10.04	11.14	12.28	13.43	14.66	15.98	17.31	18.70	20.15	21.65	23.20	24.90	26.70	28.70	30.60
		As	2.42	2.73	3.03	3.29	3.52	3.75	3.97	4.14	4.30	4.45	4.56	4.66	4.75	4.83	4.88	4.90	4.92	4.93	4.90
8′-2″	66.7	Cd	5.85	6.86	7.90	8.95	10.02	11.12	12.23	13.40	14.60	15.92	17.23	18.60	20.00	21.50	23.05	24.60	26.40	28.30	30.30
		As	2.48	2.80	3.11	3.38	3.62	3.86	4.09	4.27	4.43	4.59	4.72	4.82	4.92	5.01	5.07	5.10	5.12	5.14	5.12
8′-4″	69.4	Cd	5.85	6.86	7.89	8.94	10.00	11.10	12.20	13.37	14.55	15.85	17.15	18.50	19.85	21.35	22.90	24.40	26.15	28.00	30.00
		As	2.54	2.87	3.19	3.47	3.72	3.97	4.21	4.39	4.57	4.74	4.87	4.99	5.09	5.19	5.25	5.29	5.32	5.36	5.33
8′-6″	72.3	Cd	5.85	6.85	7.89	8.93	9.98	11.08	12.18	13.33	14.53	15.78	17.08	18.40	19.75	21.20	22.70	24.20	25.90	27.70	29.70
		As	2.60	2.94	3.27	3.56	3.82	4.08	4.33	4.52	4.70	4.88	5.03	5.15	5.26	5.37	5.44	5.49	5.53	5.57	5.55
8′-8″	75.1	Cd	5.84	6.85	7.88	8.92	9.96	11.06	12.16	13.30	14.50	15.70	17.00	18.30	19.64	21.05	22.55	24.05	25.70	27.40	29.40
		As	2.66	3.01	3.35	3.65	3.92	4.19	4.45	4.65	4.84	5.03	5.18	5.32	5.43	5.55	5.63	5.69	5.73	5.79	5.77
8′-10″	78.0	Cd	5.84	6.84	7.87	8.91	9.95	11.04	12.14	13.26	14.44	15.62	16.92	18.20	19.52	20.90	22.40	23.90	25.50	27.15	29.05
		As	2.72	3.08	3.43	3.74	4.02	4.29	4.56	4.77	4.98	5.17	5.34	5.48	5.60	5.73	5.82	5.89	5.93	6.00	5.99
9′-0″	81.0	Cd	5.83	6.84	7.86	8.90	9.94	11.02	12.12	13.24	14.40	15.56	16.82	18.10	19.40	20.80	22.22	23.70	25.30	26.90	28.75
		As	2.78	3.15	3.51	3.83	4.12	4.40	4.68	4.90	5.11	5.31	5.49	5.64	5.77	5.91	6.01	6.09	6.14	6.21	6.21
9′-2″	84.0	Cd	5.83	6.84	7.86	8.89	9.93	11.00	12.10	13.21	14.36	15.51	16.75	18.00	19.34	20.71	22.05	23.55	25.10	26.70	28.50
		As	2.84	3.22	3.59	3.92	4.22	4.51	4.80	5.02	5.25	5.46	5.65	5.81	5.94	6.09	6.19	6.28	6.34	6.43	6.43
9′-4″	87.1	Cd	5.82	6.83	7.85	8.88	9.92	10.98	12.08	13.18	14.33	15.47	16.70	17.94	19.27	20.62	21.90	23.42	24.95	26.50	28.25
		As	2.90	3.29	3.67	4.01	4.32	4.62	4.92	5.15	5.38	5.60	5.80	5.97	6.11	6.27	6.38	6.48	6.54	6.64	6.65
9′-6″	90.3	Cd	5.82	6.83	7.85	8.87	9.91	10.96	12.06	13.15	14.30	15.43	16.65	17.88	19.20	20.54	21.80	23.30	24.80	26.35	28.05
		As	2.96	3.36	3.75	4.10	4.42	4.73	5.04	5.28	5.52	5.75	5.96	6.13	6.29	6.45	6.57	6.68	6.75	6.85	6.87
9′-8″	93.4	Cd	5.81	6.82	7.85	8.86	9.90	10.94	12.04	13.14	14.27	15.39	16.60	17.82	19.14	20.45	21.70	23.20	24.68	26.20	27.85
		As	3.02	3.43	3.83	4.19	4.51	4.84	5.16	5.40	5.66	5.89	6.11	6.30	6.46	6.63	6.76	6.88	6.95	7.07	7.09
9′-10″	96.7	Cd	5.81	6.82	7.84	8.85	9.89	10.92	12.02	13.12	14.24	15.35	16.56	17.77	19.07	20.37	21.62	23.10	24.53	26.05	27.65
		As	3.08	3.50	3.91	4.28	4.61	4.94	5.27	5.53	5.79	6.04	6.27	6.46	6.63	6.81	6.95	7.08	7.15	7.28	7.31
10′-0″	100.0	Cd	5.80	6.81	7.84	8.84	9.88	10.90	12.00	13.10	14.21	15.31	16.52	17.72	19.00	20.30	21.53	23.00	24.40	25.85	27.45
		As	3.14	3.57	3.99	4.37	4.71	5.05	5.39	5.66	5.93	6.18	6.42	6.62	6.80	6.99	7.13	7.27	7.35	7.49	7.52
10′-2″	103.4	Cd	5.80	6.81	7.83	8.84	9.87	10.88	11.99	13.08	14.18	15.27	16.48	17.68	18.94	20.22	21.46	22.90	24.30	25.70	27.25
		As	3.20	3.64	4.07	4.46	4.81	5.16	5.51	5.78	6.06	6.33	6.58	6.79	6.97	7.17	7.32	7.47	7.56	7.71	7.74
10′-4″	106.8	Cd	5.80	6.81	7.83	8.83	9.86	10.87	11.98	13.06	14.16	15.24	16.44	17.64	18.87	20.15	21.40	22.80	24.20	25.55	27.05
		As	3.26	3.71	4.15	4.55	4.91	5.27	5.63	5.91	6.20	6.47	6.73	6.95	7.14	7.35	7.51	7.67	7.76	7.92	7.96
10′-6″	110.3	Cd	5.80	6.80	7.82	8.83	9.85	10.86	11.97	13.04	14.14	15.22	16.40	17.60	18.80	20.10	21.32	22.70	24.10	25.42	26.90
		As	3.34	3.78	4.23	4.64	5.01	5.38	5.75	6.04	6.34	6.61	6.89	7.11	7.31	7.53	7.70	7.87	7.96	8.13	8.18
10′-8″	113.8	Cd	5.80	6.80	7.82	8.82	9.85	10.86	11.96	13.02	14.12	15.20	16.36	17.55	18.75	20.05	21.25	22.63	24.00	25.30	26.75
		As	3.40	3.85	4.31	4.73	5.11	5.49	5.87	6.16	6.47	6.76	7.04	7.28	7.48	7.71	7.89	8.07	8.17	8.35	8.40
10′-10″	117.4	Cd	5.80	6.80	7.81	8.82	9.84	10.85	11.95	13.00	14.10	15.18	16.33	17.50	18.70	20.00	21.20	22.55	23.90	25.20	26.65
		As	3.46	3.92	4.39	4.82	5.21	5.60	5.98	6.29	6.61	6.90	7.19	7.44	7.65	7.90	8.07	8.26	8.37	8.56	8.62

If hooked bars are used, use half the number of bars shown.

TOTAL PERIMETER BARS (Σ_0) REQ'D E. W. FOR BOND

Bond stress 75 ♯/□″ for straight bars
Bond stress 150 ♯/□″ for hooked bars

SIZE	PERIMETER 1 BAR	Σ_0 Given for Column Sizes Shown, Both Straight and Hooked Bars. Number Given is for Straight Bars, E. W.																		
		12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
Σ_0 STRAIGHT =		22.0	25.6	29.3	33.0	36.6	40.3	43.9	47.6	51.2	54.9	58.5	62.2	65.8	69.5	73.1	76.8	80.4	84.0	87.7
Σ_0 HOOKED =		11.0	12.8	14.7	16.5	18.3	20.2	22.0	23.8	25.6	27.5	29.3	31.1	32.9	34.8	36.6	38.4	40.2	42.0	43.9
⅜ϕ	1.18	19	22	25	28	31	34	38	41	44	47	50	53	56	59	62	65	69	72	75
½ϕ	1.57	14	17	19	21	24	26	28	31	33	35	38	40	42	45	47	49	52	54	56
⅝ϕ	1.96	12	14	15	17	19	21	23	25	27	28	30	32	34	36	38	40	41	43	45
¾ϕ	2.36	10	11	13	14	16	17	19	21	22	24	25	27	28	30	31	33	34	36	38

AREAS OF REINFORCING BARS.

SIZE	AREA 1 BAR	WT. 1 BAR	AREAS OF VARIOUS NUMBERS OF BARS SHOWN																
			10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
⅜ϕ	.11	.38	1.10	1.21	1.32	1.43	1.54	1.65	1.76	1.87	1.98	2.09	2.20	2.31	2.42	2.53	2.64	2.75	2.86
½ϕ	.20	.68	1.96	2.16	2.35	2.55	2.74	2.94	3.14	3.33	3.53	3.72	3.92	4.12	4.31	4.51	4.70	4.90	5.10
⅝ϕ	.31	1.06	3.07	3.38	3.68	3.99	4.30	4.61	4.91	5.22	5.53	5.83	6.14	6,45	6.75	7.06	7.37	7.68	7.98
¾ϕ	.44	1.52	4.42	4.86	5.30	5.75	6.19	6.63	7.07	7.51	7.96	8.40	8.84	9.28	9.72	10.17	10.61	11.05	11.49

UNIVERSAL FOOTING TABLES

FOR SQUARE SLAB COLUMN FOOTINGS

P = Column load, in kips.
C_d = Constant for footing depth.
d = Effective depth = $\frac{P}{C_d}$
A_s = Area steel req'd for Moment, each way; latter in inch lbs., for punching shear of 120 #/□″.

Add 4″ to Depth as Found by $\frac{P}{Cd}$

F_s = 18,000

SIDE OF SQUARE FOOTING	AREA SQ. FT.	CONST	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	54	60
			SIZE SQUARE COLUMN, IN INCHES, (C)																	
11′-0″	121.0	Cd	8.82	9.84	10.85	11.94	12.98	14.08	15.15	16.30	17.47	18.67	19.95	21.15	22.47	23.75	25.10	26.55	31.15	36.40
		As	4.91	5.30	5.70	6.10	6.42	6.75	7.05	7.35	7.60	7.83	8.08	8.26	8.46	8.58	8.77	8.85	9.14	9.28
11′-2″	124.7	Cd	8.81	9.84	10.84	11.92	12.96	14.05	15.12	16.26	17.45	18.63	19.90	21.10	22.39	23.65	25.00	26.45	31.00	36.10
		As	5.00	5.40	5.81	6.22	6.55	6.89	7.20	7.50	7.77	8.01	8.27	8.46	8.66	8.80	8.99	9.08	9.40	9.56
11′-4″	128.4	Cd	8.81	9.83	10.84	11.90	12.94	14.02	15.10	16.23	17.40	18.60	19.85	21.05	22.31	23.55	24.90	26.35	30.85	35.80
		As	5.09	5.50	5.92	6.34	6.68	7.03	7.35	7.66	7.94	8.19	8.45	8.65	8.87	9.01	9.21	9.31	9.66	9.84
11′-6″	132.3	Cd	8.80	9.83	10.83	11.88	12.93	14.00	15.08	16.20	17.35	18.56	19.80	21.00	22.24	23.48	24.82	26.25	30.70	35.50
		As	5.18	5.61	6.03	6.46	6.82	7.16	7.49	7.81	8.10	8.36	8.64	8.85	9.07	9.23	9.44	9.54	9.91	10.11
11′-8″	136.1	Cd	8.80	9.82	10.82	11.86	12.92	13.98	15.06	16.18	17.30	18.52	19.75	20.95	22.17	23.42	24.74	26.15	30.55	35.25
		As	5.27	5.71	6.14	6.58	6.95	7.30	7.64	7.97	8.27	8.54	8.82	9.05	9.28	9.44	9.66	9.77	10.17	10.39
11′-10″	140.0	Cd	8.79	9.82	10.81	11.85	12.91	13.96	15.04	16.16	17.26	18.48	19.70	20.90	22.10	23.36	24.68	26.05	30.40	35.00
		As	5.36	5.81	6.26	6.70	7.08	7.44	7.79	8.12	8.44	8.72	9.01	9.24	9.48	9.66	9.88	10.01	10.43	10.67
12′-0″	144.0	Cd	8.79	9.81	10.80	11.84	12.90	13.94	15.02	16.14	17.22	18.44	19.65	20.85	22.04	23.30	24.60	25.95	30.25	34.80
		As	5.45	5.92	6.36	6.82	7.21	7.58	7.94	8.28	8.61	8.90	9.20	9.44	9.68	9.87	10.10	10.24	10.69	10.95
12′-2″	148.0	Cd	8.78	9.80	10.79	11.83	12.89	13.92	15.00	16.12	17.20	18.40	19.60	20.80	22.00	23.24	24.54	25.85	30.10	34.60
		As	5.54	6.02	6.48	6.94	7.34	7.72	8.09	8.43	8.78	9.08	9.38	9.64	9.89	10.09	10.32	10.47	10.95	11.23
12′-4″	152.1	Cd	8.78	9.79	10.78	11.82	12.88	13.90	14.98	16.10	17.18	18.36	19.55	20.75	21.95	23.18	24.47	25.78	29.95	34.40
		As	5.63	6.12	6.59	7.06	7.48	7.86	8.23	8.59	8.94	9.25	9.57	9.83	10.09	10.30	10.55	10.70	11.20	11.50
12′-6″	156.3	Cd	8.77	9.78	10.77	11.81	12.87	13.89	14.96	16.08	17.16	18.32	19.50	20.70	21.90	23.13	24.40	25.70	29.80	34.20
		As	5.72	6.22	6.70	7.18	7.61	8.00	8.38	8.74	9.11	9.43	9.75	10.03	10.30	10.52	10.77	10.93	11.46	11.78
12′-8″	160.4	Cd	8.77	9.77	10.76	11.80	12.86	13.88	14.94	16.06	17.14	18.28	19.45	20.65	21.85	23.06	24.35	25.65	29.65	34.05
		As	5.81	6.32	6.81	7.30	7.74	8.14	8.53	8.90	9.28	9.61	9.94	10.23	10.50	10.73	10.99	11.16	11.72	12.06
12′-10″	164.7	Cd	8.77	9.76	10.75	11.79	12.85	13.87	14.92	16.04	17.12	18.25	19.40	20.60	21.80	23.00	24.30	25.60	29.50	33.90
		As	5.90	6.42	6.92	7.42	7.87	8.27	8.68	9.05	9.45	9.79	10.13	10.42	10.70	10.95	11.21	11.39	11.98	12.34
13′-0″	169.0	Cd	8.76	9.75	10.75	11.78	12.84	13.86	14.91	16.02	17.10	18.22	19.35	20.57	21.75	22.92	24.22	25.55	29.40	33.80
		As	5.99	6.52	7.03	7.54	8.00	8.41	8.83	9.20	9.62	9.97	10.31	10.62	10.91	11.16	11.43	11.62	12.24	12.62
13′-2″	173.4	Cd	8.76	9.75	10.75	11.78	12.83	13.85	14.90	16.00	17.09	18.20	19.30	20.55	21.70	22.85	24.15	25.50	29.30	33.70
		As	6.08	6.63	7.14	7.66	8.14	8.55	8.97	9.36	9.78	10.14	10.50	10.81	11.11	11.38	11.66	11.85	12.49	12.89
13′-4″	177.8	Cd	8.76	9.75	10.75	11.78	12.82	13.85	14.89	15.99	17.08	18.18	19.25	20.53	21.65	22.80	24.10	25.45	29.25	33.60
		As	6.17	6.73	7.25	7.78	8.27	8.69	9.12	9.51	9.95	10.32	10.68	11.01	11.32	11.59	11.88	12.08	12.75	13.17
13′-6″	182.3	Cd	8.76	9.75	10.75	11.77	12.81	13.83	14.88	15.97	17.06	18.16	19.23	20.47	21.60	22.75	24.00	25.37	29.15	33.40
		As	6.26	6.83	7.37	7.90	8.40	8.83	9.27	9.67	10.12	10.50	10.87	11.21	11.52	11.81	12.10	12.32	13.01	13.45
13′-8″	186.8	Cd	8.76	9.75	10.75	11.76	12.80	13.81	14.87	15.95	17.04	18.14	19.22	20.42	21.55	22.70	23.90	25.30	29.05	33.20
		As	6.35	6.93	7.48	8.02	8.53	8.97	9.42	9.82	10.29	10.68	11.06	11.40	11.72	12.02	12.32	12.55	13.27	13.73
13′-10″	191.4	Cd	8.76	9.75	10.75	11.76	12.80	13.80	14.86	15.93	17.02	18.13	19.21	20.36	21.50	22.68	23.85	25.22	28.97	33.05
		As	6.45	7.03	7.59	8.14	8.66	9.10	9.57	9.98	10.46	10.86	11.24	11.60	11.93	12.24	12.54	12.78	13.53	14.01
14′-0″	196.0	Cd		9.75	10.75	11.75	12.79	13.79	14.85	15.92	17.00	18.12	19.20	20.30	21.45	22.65	23.80	25.15	28.90	32.90
		As		7.14	7.70	8.26	8.80	9.24	9.71	10.13	10.62	11.03	11.43	11.80	12.13	12.45	12.77	13.01	13.78	14.28
14′-2″	200.7	Cd		9.75	10.75	11.75	12.79	13.78	14.84	15.91	16.99	18.11	19.19	20.29	21.43	22.63	23.78	25.07	28.82	32.80
		As		7.24	7.81	8.38	8.93	9.38	9.86	10.29	10.79	11.21	11.61	11.99	12.34	12.67	12.99	13.24	14.04	14.56
14′-4″	205.4	Cd		9.75	10.75	11.75	12.79	13.77	14.83	15.90	16.98	18.10	19.18	20.25	21.40	22.60	23.75	25.00	28.75	32.70
		As		7.34	7.92	8.50	9.06	9.52	10.01	10.44	10.96	11.39	11.80	12.19	12.54	12.88	13.21	13.47	14.30	14.84
14′-6″	210.3	Cd		9.75	10.75	11.75	12.79	13.76	14.82	15.89	16.97	18.09	19.17	20.24	21.38	22.58	23.73	24.95	28.70	32.62
		As		7.44	8.03	8.62	9.19	9.66	10.16	10.59	11.13	11.57	11.99	12.39	12.74	13.10	13.43	13.70	14.56	15.12
14′-8″	215.1	Cd		9.75	10.75	11.75	12.79	13.75	14.81	15.86	16.96	18.08	19.16	20.23	21.35	22.55	23.70	24.90	28.65	32.55
		As		7.54	8.14	8.74	9.32	9.80	10.31	10.75	11.30	11.75	12.17	12.58	12.95	13.31	13.65	13.93	14.82	15.40
14′-10″	220.0	Cd		9.75	10.75	11.75	12.78	13.75	14.80	15.86	16.95	18.07	19.15	20.22	21.33	22.53	23.68	24.85	28.60	32.47
		As		7.65	8.25	8.86	9.46	9.94	10.45	10.90	11.46	11.92	12.36	12.78	13.15	13.53	13.88	14.16	15.07	15.67
15′-0″	225.0	Cd		9.75	10.75	11.75	12.78	13.75	14.79	15.86	16.94	18.06	19.14	20.21	21.30	22.50	23.65	24.80	28.55	32.40
		As		7.75	8.37	8.98	9.58	10.07	10.60	11.06	11.64	12.10	12.55	12.98	13.36	13.74	14.10	14.40	15.32	15.96

If hooked bars are used, use half the number of bars shown.

TOTAL PERIMETER BARS (Σ_0) REQ'D. FOR BOND

Bond stress 75 #/□″ for straight def. bars
Bond stress 150 #/□″ for hooked def. bars

Σ_0 Given for Column Sizes Shown, Both Straight and Hooked Bars. Number Given is for Straight Bars, E. W.

SIZE	PERIMETER 1 BAR	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	54	60
Σ_0 STRAIGHT =		33.0	36.6	40.3	43.9	47.6	51.2	54.9	58.5	62.2	65.8	69.5	73.1	76.8	80.4	84.0	87.7	98.6	109.6
Σ_0 HOOKED =		16.5	18.3	20.2	22.0	23.8	25.6	27.5	29.3	31.1	32.9	34.8	36.6	38.4	40.2	42.0	43.9	49.3	54.8
½φ	1.57	21	24	26	28	31	33	35	38	40	42	45	47	49	52	54	56	63	70
⅝φ	1.96	17	19	21	23	25	27	28	30	32	34	36	38	40	41	43	45	51	56
¾φ	2.36	14	16	17	19	21	22	24	25	27	28	30	31	33	34	36	38	42	47
⅞φ	2.75	12	14	15	16	18	19	20	22	23	24	26	27	28	30	31	32	36	40

AREAS OF REINFORCING BARS.

SIZE	AREA 1 BAR	WT. 1 BAR	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
			AREAS OF VARIOUS NUMBERS OF BARS SHOWN																		
½φ	.20	.68	3.14	3.33	3.53	3.72	3.92	4.12	4.31	4.51	4.70	4.90	5.10	5.29	5.49	5.68	5.88	6.08	6.27	6.47	6.66
⅝φ	.31	1.06	4.91	5.22	5.53	5.83	6.14	6.45	6.75	7.06	7.37	7.68	7.98	8.29	8.60	8.90	9.21	9.52	9.82	10.13	10.44
¾φ	.44	1.52	7.07	7.51	7.96	8.40	8.84	9.28	9.72	10.17	10.61	11.05	11.49	11.93	12.38	12.82	13.26	13.70	14.14	14.59	15.03
⅞φ	.60	2.04	9.62	10.22	10.82	11.42	12.02	12.62	13.22	13.82	14.42	15.03	15.63	15.23	16.83	17.43	18.03	18.63	19.23	19.83	20.43

SQUARE COLUMN FOOTINGS

DIRECT VALUES OF K_1

Tabulated Values of K_1 Derived From Ratios of $\frac{c}{l}$ or $\frac{c+2d}{l}$

SIZE FOOTING		Width of Column = c or Total of $c + 2d$																								
FT.	IN.	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58
2	6	.223	.210	.196	.179	.160	.140	.116	.090																	
	8	.226	.215	.203	.188	.171	.153	.132	.109																	
	10	.228	.220	.208	.195	.180	.164	.145	.125	.104																
3	0	.231	.223	.212	.201	.188	.173	.157	.139	.119	.099															
	2	.233	.225	.216	.206	.194	.181	.166	.150	.133	.115	.094														
	4	.234	.227	.220	.210	.199	.188	.174	.160	.144	.128	.109	.090													
	6	.236	.230	.223	.214	.205	.194	.181	.169	.154	.139	.122	.105													
	8	.237	.232	.225	.217	.208	.198	.188	.176	.162	.149	.133	.118	.101												
	10	.238	.233	.227	.220	.212	.203	.193	.182	.171	.158	.143	.129	.113	.097											
4	0	.239	.234	.229	.223	.215	.207	.198	.188	.176	.165	.153	.139	.124	.109	.093										
	2	.240	.236	.231	.224	.218	.210	.202	.193	.182	.172	.160	.148	.134	.120	.106	.090									
	4	.241	.237	.232	.226	.221	.213	.206	.197	.188	.178	.167	.156	.143	.130	.117	.102									
	6	.242	.238	.233	.228	.223	.216	.209	.201	.192	.182	.173	.162	.151	.139	.126	.113	.099								
	8	.243	.239	.234	.230	.224	.219	.212	.204	.196	.188	.179	.168	.158	.147	.134	.122	.109	.095							
	10	.243	.239	.236	.231	.226	.221	.214	.207	.200	.191	.183	.174	.164	.154	.143	.131	.119	.106	.093						
5	0	.243	.240	.237	.232	.227	.222	.217	.210	.203	.195	.187	.179	.170	.160	.150	.139	.128	.116	.103	.090					
	2	.243	.241	.238	.233	.229	.224	.220	.213	.206	.199	.191	.184	.175	.166	.156	.146	.135	.124	.112	.100					
	4	.244	.241	.238	.234	.231	.226	.221	.215	.209	.203	.195	.188	.180	.171	.162	.153	.143	.132	.120	.109	.097				
	6	.244	.242	.239	.235	.232	.227	.223	.217	.211	.205	.198	.191	.184	.176	.168	.158	.149	.139	.129	.118	.107	.095			
	8	.244	.242	.239	.236	.233	.228	.224	.220	.214	.208	.201	.195	.188	.180	.172	.164	.155	.145	.135	.125	.116	.104	.092		
	10	.245	.243	.240	.237	.233	.230	.225	.221	.216	.210	.204	.198	.191	.184	.176	.168	.160	.151	.142	.133	.122	.112	.101	.090	
6	0	.245	.243	.240	.238	.234	.231	.227	.222	.218	.212	.207	.201	.194	.188	.181	.173	.165	.156	.148	.139	.130	.119	.109	.099	
	2	.245	.244	.241	.239	.235	.232	.228	.223	.220	.214	.209	.204	.197	.191	.184	.177	.170	.162	.153	.144	.136	.127	.117	.107	.096
	4	.246	.244	.241	.239	.236	.233	.229	.225	.221	.216	.211	.206	.200	.194	.188	.181	.173	.166	.159	.150	.142	.133	.124	.115	.105
	6	.246	.244	.242	.240	.237	.233	.231	.226	.222	.218	.213	.208	.203	.197	.191	.184	.177	.171	.163	.156	.147	.139	.130	.121	.111
	8	.246	.244	.242	.240	.238	.234	.232	.227	.224	.220	.215	.210	.205	.200	.194	.188	.181	.174	.168	.160	.153	.144	.136	.128	.119
	10	.246	.245	.243	.241	.238	.235	.233	.229	.225	.221	.217	212	.207	.202	.197	.191	.184	.178	.172	.165	.157	.150	.141	.133	.125
7	0	.246	.245	.243	.241	.239	.236	.233	.230	.226	.223	.219	.214	.209	.204	.199	.194	.188	.181	.175	.168	.162	.154	.147	.139	.131
	2	.247	.245	.243	.242	.239	.237	.234	.231	.227	.224	.220	.216	.211	.206	.201	.196	.191	.184	.179	.173	.165	.159	.152	.143	.136
	4	.247	.245	.244	.242	.240	.237	.234	.232	.228	.225	.221	.218	.213	.208	.203	.198	.193	.188	.182	.176	.170	.163	.156	.149	.141
	6	.247	.246	.244	.242	.240	.238	.235	.232	.229	.226	.222	.219	.215	.210	.205	.201	.196	.191	.185	.179	.173	.167	.160	.153	.146
	8	.247	.246	.244	.243	.241	.238	.236	.233	.230	.227	.223	.220	.217	.212	.207	.203	.198	.193	.188	.182	.176	.171	.164	.158	.151
	10	.248	.246	.244	.243	.241	.239	.236	.234	.231	.228	.224	.221	.218	.214	.209	.205	.200	.196	.191	.185	.179	.174	.168	.162	.155
8	0		.246	.245	.243	.241	.239	.237	.235	.232	.229	.225	.222	.219	.215	.211	.207	.202	.198	.193	.188	.182	.176	.171	.165	.159
	2		.246	.245	.243	.242	.240	.237	.235	.233	.230	.226	.223	.220	.217	.213	.209	.204	.199	.195	.191	.185	.180	.174	.169	.162
	4		.246	.245	.244	.242	.240	.238	.236	.234	.231	.227	.224	.221	.218	.215	.210	.206	.202	.197	.193	.188	.182	.177	.172	.166
	6		.247	.245	.244	.242	.241	.238	.236	.235	.232	.228	.225	.222	.219	.216	.212	.208	.204	.199	.195	.191	.185	.180	.174	.169
	8		.247	.245	.244	.243	.241	.239	.237	.235	.232	.229	.226	.223	.220	.217	.213	.209	.206	.201	.197	.193	.188	.182	.177	.173
	10		.247	.246	.244	.243	.241	.239	.237	.236	.233	.230	.227	.224	.221	.219	.215	.211	.207	.203	.199	.195	.191	.185	.180	.175
9	0			.246	.244	.243	.242	.240	.238	.236	.233	.231	.228	.225	.222	.220	.216	.212	.209	.205	.201	.197	.192	.188	.183	.178
	2			.246	.245	.244	.242	.240	.238	.237	.234	.232	.229	.226	.223	.221	.217	.214	.210	.207	.203	.198	.194	.190	.185	.181
	4			.246	.245	.244	.242	.241	.239	.237	.234	.232	.230	.227	.224	.222	.219	.215	.212	.208	.205	.201	.196	.192	.188	.183
	6			.246	.245	.244	.243	.241	.239	.237	.235	.233	.231	.228	.225	.223	.220	.217	.213	.210	.206	.203	.198	.194	.190	.186
	8			.246	.245	.244	.243	.241	.239	.238	.236	.233	.232	.229	.226	.223	.221	.218	.214	.211	.207	.204	.199	.196	.192	.188
	10			.246	.246	.244	.243	.242	.240	.238	.236	.234	.232	.230	.227	.224	.221	.219	.215	.212	.209	.206	.202	.197	.194	.190
10	0				.246	.244	.243	.242	.240	.239	.237	.234	.233	.231	.227	.225	.222	.220	.217	.214	.210	.207	.203	.199	.196	.192
	2				.246	.244	.244	.242	.240	.239	.237	.235	.233	.231	.228	.226	.223	.221	.218	.215	.211	.208	.205	.201	.197	.194
	4				.246	.245	.244	.242	.241	.239	.238	.235	.233	.232	.229	.227	.224	.222	.219	.216	.213	.210	.206	.203	.199	.196
	6				.246	.245	.244	.243	.241	.240	.238	.236	.234	.232	.230	.227	.225	.223	.220	.217	.214	.211	.208	.204	.201	.197
	8				.246	.245	.244	.243	.241	.240	.238	.236	.234	.233	.231	.228	.226	.223	.221	.218	.215	.212	.209	.206	.203	.199
	10				.246	.245	.244	.243	.242	.240	.239	.237	.235	.233	.231	.229	.226	.224	.221	.219	.216	.213	.210	.207	.204	.201
11	0					.246	.244	.243	.242	.240	.239	.237	.235	.234	.232	.230	.227	.225	.222	.220	.217	.214	.211	.208	.205	.202
	2					.246	.244	.244	.242	.241	.239	.238	.236	.234	.232	.230	.227	.226	.223	.221	.218	.215	.212	.209	.207	.204
	4					.246	.244	.244	.243	.241	.240	.238	.237	.235	.233	.231	.228	.226	.224	.222	.219	.217	.214	.210	.208	.205
	6					.246	.245	.244	.243	.241	.240	.238	.237	.235	.233	.231	.229	.227	.224	.223	.220	.218	.215	.212	.209	.206
	8					.246	.245	.244	.243	.242	.240	.239	.237	.236	.233	.232	.230	.227	.225	.223	.221	.219	.216	.213	.210	.207
	10					.246	.245	.244	.243	.242	.240	.239	.238	.236	.234	.232	.231	.228	.226	.224	.222	.220	.217	.214	.211	.209
12	0						.245	.244	.244	.242	.241	.239	.238	.237	.234	.233	.231	.229	.227	.224	.223	.221	.218	.215	.212	.210
	2						.245	.244	.244	.242	.241	.240	.238	.237	.235	.233	.232	.230	.227	.225	.223	.221	.219	.216	.213	.211
	4						.246	.244	.244	.243	.241	.240	.239	.237	.235	.233	.232	.230	.228	.226	.224	.222	.220	.217	.214	.212
	6						.246	.244	.244	.243	.241	.240	.239	.237	.236	.234	.233	.231	.228	.227	.224	.223	.221	.218	.215	.213
	8						.246	.245	.244	.243	.242	.240	.239	.238	.236	.234	.233	.232	.229	.227	.225	.223	.221	.219	.216	.214
	10						.246	.245	.244	.243	.242	.240	.239	.238	.237	.235	.233	.232	.230	.228	.226	.224	.222	.220	.217	.215
13	0							.245	.244	.244	.242	.241	.240	.238	.237	.235	.234	.232	.231	.228	.226	.224	.222	.221	.218	.216
	2							.245	.244	.244	.242	.241	.240	.239	.237	.236	.234	.233	.231	.229	.227	.225	.223	.221	.219	.217
	4							.245	.244	.244	.243	.241	.240	.239	.238	.236	.234	.233	.232	.230	.227	.226	.224	.222	.220	.218
	6							.246	.244	.244	.243	.242	.240	.239	.238	.237	.235	.233	.232	.230	.228	.226	.224	.222	.221	.219
	8							.246	.245	.244	.243	.242	.241	.239	.238	.237	.235	.234	.232	.231	.229	.227	.225	.223	.221	.220
	10							.246	.245	.244	.243	.242	.241	.240	.238	.238	.236	.234	.233	.231	.229	.227	.225	.223	.222	.220
14	0								.245	.244	.243	.242	.241	.240	.239	.238	.236	.234	.233	.232	.230	.228	.226	.224	.222	.221
	2								.245	.244	.244	.243	.241	.240	.239	.238	.237	.235	.233	.232	.231	.228	.227	.225	.223	.221
	4								.245	.244	.244	.243	.242	.240	.239	.238	.237	.235	.234	.232	.231	.229	.227	.225	.224	.222
	6								.245	.244	.244	.243	.242	.241	.239	.238	.237	.236	.234	.233	.232	.230	.227	.226	.224	.222
	8								.246	.244	.244	.243	.242	.241	.240	.239	.237	.236	.234	.233	.232	.230	.228	.227	.225	.223
	10								.246	.245	.244	.243	.242	.241	.240	.239	.238	.237	.235	.233	.232	.231	.228	.227	.225	.224
15	0								.246	.245	.244	.243	.242	.241	.240	.239	.238	.237	.235	.234	.233	.231	.229	.227	.226	.224

SQUARE COLUMN FOOTINGS

DIRECT VALUES OF K_1

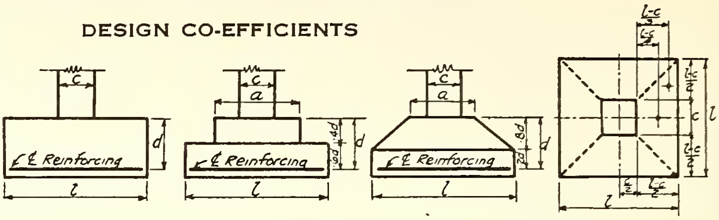
Tabulated Values of K_1 Derived From Ratios of $\frac{c}{l}$ or $\frac{c+2d}{l}$

SIZE FOOTING		Width of Column $= c$ or Total of $c + 2d$																								
FT.	IN.	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108
2	6																									
	8																									
	10																									
3	0																									
	2																									
	4																									
	6																									
	8																									
	10																									
4	0																									
	2																									
	4																									
	6																									
	8																									
	10																									
5	0																									
	2																									
	4																									
	6																									
	8																									
	10																									
6	0																									
	2																									
	4	.094																								
	6	.102	.092																							
	8	.109	.100	.090																						
	10	.116	.107	.098																						
7	0	.122	.115	.105	.096																					
	2	.129	.119	.111	.103	.094																				
	4	.133	.126	.118	.109	.100	.092																			
	6	.140	.131	.124	.116	.108	.099	.090																		
	8	.143	.136	.130	.121	.113	.106	.097	.088																	
	10	.149	.141	.134	.127	.119	.111	.103	.095	.086																
8	0	.153	.145	.139	.132	.124	.117	.109	.102	.094																
	2	.156	.150	.143	.137	.130	.122	.116	.108	.100	.091															
	4	.160	.154	.148	.141	.134	.128	.120	.113	.106	.098	.090														
	6	.164	.158	.152	.145	.139	.133	.126	.119	.111	.104	.096	.089													
	8	.167	.162	.156	.150	.143	.137	.130	.123	.117	.109	.102	.095													
	10	.171	.165	.159	.153	.147	.141	.134	.129	.121	.116	.108	.100	.093												
9	0	.173	.168	.162	.157	.151	.145	.139	.133	.127	.120	.113	.106	.099	.092											
	2	.176	.171	.166	.160	.155	.149	.143	.137	.131	.124	.118	.111	.104	.097	.090										
	4	.179	.174	.169	.163	.159	.153	.147	.141	.135	.129	.122	.116	.109	.103	.096	.089									
	6	.181	.176	.172	.166	.161	.156	.150	.144	.139	.133	.127	.120	.115	.108	.101	.094									
	8	.183	.179	.174	.169	.165	.159	.154	.149	.143	.137	.131	.125	.119	.113	.106	.100	.093								
	10	.186	.181	.176	.172	.168	.162	.157	.152	.146	.141	.135	.130	.123	.117	.111	.105	.098	.091							
10	0	.188	.184	.179	.174	.171	.165	.160	.155	.150	.144	.140	.133	.128	.121	.116	.109	.103	.097	.090						
	2	.190	.186	.181	.177	.173	.168	.163	.158	.153	.148	.143	.137	.131	.126	.120	.115	.108	.102	.095	.089					
	4	.192	.188	.184	.179	.175	.171	.166	.161	.156	.151	.146	.140	.135	.130	.124	.119	.112	.107	.100	.094					
	6	.194	.190	.186	.181	.177	.173	.169	.164	.159	.154	.150	.144	.139	.133	.128	.122	.117	.111	.105	.100	.093				
	8	.196	.191	.188	.184	.180	.175	.171	.167	.161	.157	.153	.148	.142	.137	.132	.126	.120	.116	.109	.104	.097	.091			
	10	.197	.193	.190	.186	.182	.178	.173	.169	.165	.160	.156	.151	.145	.140	.135	.130	.125	.119	.113	.108	.102	.096	.090		
11	0	.198	.195	.191	.188	.184	.180	.176	.172	.168	.163	.159	.154	.149	.143	.139	.133	.129	.123	.118	.112	.107	.101	.095	.089	
	2	.200	.197	.193	.189	.186	.182	.178	.174	.170	.165	.161	.156	.152	.147	.142	.137	.132	.127	.121	.116	.111	.106	.100	.094	
	4	.202	.198	.195	.191	.188	.184	.180	.176	.172	.168	.164	.159	.155	.150	.145	.140	.136	.130	.125	.120	.116	.109	.104	.098	.093
	6	.203	.199	.196	.193	.190	.186	.182	.179	.174	.171	.166	.162	.157	.153	.149	.143	.140	.134	.130	.124	.119	.113	.108	.103	.097
	8	.205	.201	.198	.195	.191	.188	.184	.180	.176	.173	.168	.165	.160	.156	.152	.147	.143	.137	.133	.128	.122	.117	.112	.107	.101
	10	.206	.203	.199	.196	.193	.190	.186	.182	.179	.175	.171	.167	.163	.159	.154	.150	.145	.140	.136	.131	.126	.121	.116	.111	.106
12	0	.207	.204	.201	.197	.194	.191	.188	.184	.181	.177	.173	.169	.165	.161	.157	.153	.148	.143	.139	.134	.130	.125	.119	.115	.109
	2	.208	.205	.203	.199	.196	.192	.190	.186	.182	.179	.175	.171	.168	.163	.159	.155	.151	.147	.142	.137	.133	.128	.123	.119	.113
	4	.209	.207	.204	.201	.197	.194	.191	.188	.184	.181	.177	.173	.170	.166	.162	.158	.154	.150	.145	.140	.136	.131	.127	.122	.117
	6	.210	.208	.205	.202	.199	.196	.192	.190	.186	.182	.179	.175	.172	.168	.164	.160	.157	.153	.148	.143	.139	.134	.130	.126	.120
	8	.211	.209	.206	.203	.200	.197	.194	.191	.188	.184	.181	.177	.174	.171	.166	.162	.159	.155	.150	.146	.142	.137	.133	.129	.124
	10	.212	.210	.207	.204	.202	.198	.196	.192	.190	.186	.182	.179	.176	.173	.168	.165	.161	.157	.153	.149	.145	.140	.136	.132	.127
13	0	.213	.211	.208	.206	.203	.199	.197	.194	.191	.188	.184	.181	.178	.175	.170	.167	.163	.159	.156	.152	.148	.143	.139	.135	.130
	2	.214	.212	.209	.207	.204	.201	.198	.196	.192	.189	.186	.182	.180	.176	.172	.169	.165	.162	.158	.154	.150	.146	.142	.138	.133
	4	.215	.213	.210	.208	.205	.203	.199	.197	.194	.191	.188	.184	.181	.178	.174	.171	.168	.164	.160	.156	.153	.149	.144	.140	.136
	6	.216	.214	.211	.209	.206	.204	.201	.198	.195	.192	.189	.186	.183	.180	.176	.173	.170	.166	.162	.159	.155	.151	.147	.143	.139
	8	.217	.215	.212	.210	.207	.205	.202	.199	.196	.194	.191	.188	.184	.181	.178	.175	.172	.168	.165	.161	.157	.153	.150	.146	.141
	10	.218	.216	.213	.211	.208	.206	.203	.201	.198	.195	.192	.189	.186	.183	.180	.177	.173	.170	.167	.163	.159	.156	.152	.148	.144
14	0	.219	.216	.214	.212	.209	.207	.205	.202	.199	.196	.194	.191	.188	.184	.182	.179	.175	.172	.169	.165	.162	.158	.154	.150	.147
	2	.220	.217	.215	.213	.210	.208	.206	.203	.200	.197	.195	.192	.189	.186	.183	.181	.176	.174	.171	.167	.164	.160	.156	.153	.150
	4	.220	.218	.216	.213	.211	.209	.207	.204	.201	.198	.196	.193	.191	.188	.184	.182	.178	.176	.173	.169	.166	.162	.159	.155	.152
	6	.221	.219	.217	.214	.212	.210	.208	.205	.203	.200	.197	.195	.192	.189	.186	.183	.180	.177	.174	.171	.168	.164	.161	.157	.154
	8	.221	.220	.217	.215	.213	.211	.208	.206	.204	.201	.198	.196	.193	.191	.188	.184	.182	.179	.176	.173	.170	.166	.163	.159	.156
	10	.222	.220	.218	.216	.214	.212	.209	.207	.205	.203	.199	.197	.194	.192	.189	.186	.183	.181	.177	.174	.171	.168	.165	.161	.158
15	0	.222	.221	.219	.217	.215	.212	.210	.208	.206	.204	.201	.198	.196	.193	.190	.188	.184	.182	.179	.176	.173	.170	.167	.163	.160

SQUARE COLUMN FOOTINGS

DESIGN CO-EFFICIENTS

$\frac{c}{l}$	STEPPED FOOTING "a"	SLOPED FOOTING "a"	SLOPED FOOTING "d_2"
0.10	$0.36l$	$0.30l$	$0.2d$
0.15	$0.38l$	$0.31l$	$0.2d$
0.20	$0.40l$	$0.32l$	$0.2d$
0.25	$0.45l$	$0.34l$	$0.2d$
0.30	$0.50l$	$0.35l$	$0.2d$
0.35	$0.52l$	$0.40l$	$0.2d$
0.40	$0.55l$	$0.45l$	$0.2d$



VALUES OF K_1 AND K'_1

$\frac{c}{l}$	K_1	$\frac{c}{l}$	K_1	$\frac{c}{l}$	K_1	$\frac{c}{l}$	K_1
.06	.249	.20	.240	.34	.221	.48	.192
.07	.249	.21	.239	.35	.220	.49	.190
.08	.248	.22	.238	.36	.218	.50	.188
.09	.248	.23	.237	.37	.216	.52	.182
.10	.248	.24	.236	.38	.214	.54	.177
.11	.247	.25	.234	.39	.212	.56	.172
.12	.246	.26	.233	.40	.210	.58	.166
.13	.246	.27	.232	.41	.208	.60	.160
.14	.245	.28	.231	.42	.206	.62	.154
.15	.244	.29	.229	.43	.204	.64	.148
.16	.244	.30	.227	.44	.202	.66	.141
.17	.243	.31	.226	.45	.199	.68	.134
.18	.242	.32	.224	.46	.197	.70	.128
.19	.241	.33	.223	.47	.195	.72	.120

VALUES OF K_2

$\frac{c}{l}$	K_2	$\frac{c}{l}$	K_2	$\frac{c}{l}$	K_2	$\frac{c}{l}$	K_2
.06	.0758	.20	.0587	.34	.0425	.48	.0279
.07	.0746	.21	.0575	.35	.0414	.49	.0270
.08	.0733	.22	.0563	.36	.0402	.50	.0260
.09	.0721	.23	.0552	.37	.0392	.52	.0242
.10	.0709	.24	.0540	.38	.0381	.54	.0224
.11	.0697	.25	.0528	.39	.0371	.56	.0207
.12	.0685	.26	.0516	.40	.0360	.58	.0190
.13	.0672	.27	.0505	.41	.0349	.60	.0173
.14	.0660	.28	.0493	.42	.0339	.62	.0158
.15	.0647	.29	.0482	.43	.0329	.64	.0143
.16	.0635	.30	.0470	.44	.0319	.66	.0128
.17	.0622	.31	.0459	.45	.0309	.68	.0114
.18	.0610	.32	.0447	.46	.0299	.70	.0101
.19	.0600	.33	.0436	.47	.0289	.72	.0089

$$K_1 = \frac{1}{4}\left[1 - \left(\frac{c}{l}\right)^2\right]; \quad K'_1 = \frac{1}{4}\left[1 - \left(\frac{c+2d}{l}\right)^2\right]; \quad K_2 = \frac{1}{24}\left(1 - \frac{c}{l}\right)^2\left(2 + \frac{c}{l}\right)$$

Depth for Punching Shear $= d = K_1 \dfrac{P}{cv}$ Diagonal Tension $= v = \dfrac{K'_1 P}{(c+2d)\,jd}$

Area of Tensile Steel $= A_s = K_2 Pl \div f_s jd$ Bond Stress $= u = K_1\,(P \div \Sigma_0 jd)$

All sizes and types of square column footings may be designed by the use of the above tables of K_1 and K_2.

SLAB FOOTING:

Column load 350000#. Column size 28 × 28. Soil pressure 4000 #/□′. From graph, total load = 386000#.

Area footing $= \dfrac{386000}{4000} = 96.6$□′. Size 9′-10″ × 9′-10″. $\dfrac{c}{l} = \dfrac{28}{118} = .237.$ $K_1 = .2365.$ $K_2 = .0544.$

$d = .2365 \times \dfrac{350000}{28 \times 120} = 24.6''$. $A_s = \dfrac{.0544 \times 350000 \times 118}{18000 \times .875 \times 24.6} = 5.80$□″. Req. 29 ½$\phi$ bars; Add 1 bar e. s.

Σ_0 of 29 ½ϕ bars $= 29 \times 1.57 = 45.5''$. $u = .2365 \times \dfrac{350000}{45.5 \times .875 \times 24.6} = 84.5$#. Too high.

For $u = 75$#. Σ_0 required $= .2365 \times \dfrac{350000}{75 \times .875 \times 24.6} = 51.2''$ or $51.2 \div 1.57 = 33$ ½ϕ bars.

Diagonal tension @ point $c + 2d$: ratio $(c + 2d) \div l = .655$ and $K_1 = .143$

$$v = \frac{.143 \times 350000}{(28 + 49.2) \times .875 \times 24.6} = 30.1 \text{ \#/□}''$$

STEPPED FOOTING:

Same design data. Effective depth at face of column, 24.6″. Ratio $\dfrac{c}{l} = .237$ with K_1 and K_2 as above.

With ratio of .237, required width of top block is $0.45l$ or $0.45 \times 118 = 53''$. Use 54″.

Minimum depth bottom block shown @ $0.6d = 0.6 \times 24.6 = 14.75''$.

Bending moment, area of steel, and bond at face of column same as for slab footing.

Bond at edge upper block must be investigated. Formula as above, but K_1 must be based on ratio of top block to bottom block. This ratio is $54 \div 118 = .457$ and $K_1 = 0.198$.

Therefore, $u = .198 \times \dfrac{350000}{45.5 \times .875 \times 14.75} = 118$#. Use hooked bars, allowable bond 150 #/□″.

Diagonal tension governs in bottom block at section $c + 2d = 77.2''$ with $K'_1 = .143$.

$v = \dfrac{.143 \times 350000}{77.2 \times .875 \times 14.75} = 50.2$ #/□″. This is satisfactory for hooked bars (all. 60#/□″). For straight bars, d_1 should be $14.75 \times (50.2 \div 40) = 18.5''$.

SLOPED FOOTING:

Design same as for stepped footings, except that top width, "a", for $c \div l = .237$, is $0.34l = .34 \times 118 = 40''$.

The depth for punching shear, and moment and bond at face of column, are the same as for slab or stepped footings. For a slope as found from proper design, bond need only be investigated at column face. Diagonal tension must be investigated at the section $c + 2d$, and the depth at that point made sufficient to maintain the stress within design limits. The formula is $d_1 = K_1 P \div (c + 2d)\,jv$

RECTANGULAR FOOTINGS

TYPICAL DESIGN

It frequently becomes necessary, for architectural or other reasons, to use rectangular columns. When this is done, rectangular footing should also be used, with equal projection on all sides of column.

DESIGN EXAMPLE:

Assume it is desired to carry a column load of 350000 lbs. on a 22″x36″ column, with allowable soil pressure of 4000 #/□′. The area of footing is found as before, and requires approximately 100□′. From the table of economical sizes of rectangular footings, for a value of *e-c* of 14″ (36-22), the footing size will be 9′-6″ × 10′-7″; 9′-6″ × 10′-6″ will be used.

The ratio of e/l is $36/126 = .286$ and for c/s is $22/114 = .193$. The formula for depth by punching shear is, $d = K_3 \dfrac{P}{(c+e)v}$

For the ratios given the graph shows value of K_3 of .47, and the required depth,

$$d = .47 \frac{350000}{(22+36)\ 120} = 23.7'', \text{ say } 24''.$$

The values of K_5 for Bending Moment are found from the K_5 graph, based on the values of e/l and c/s of .286 and .193 respectively. For the long side of the cantilever, K_5 is found where the e/l diagonal line of .286 crosses the vertical c/s line of .193, the result being .0466, and by transposition, .193 on the e/l diagonal line, intersecting .286 on the vertical line gives a value of .0621 for the short side.

Then, $M_l = K_5Pl = .0466 \times 350000 \times 10.5 \times 12 = 2{,}060{,}000$ in. lbs.

$M_s = K_5P_s = .0621 \times 350000 \times 9.5 \times 12 = 2{,}475{,}000$ in. lbs.

The required area of steel, $(A_s) = \dfrac{M}{jdf_s}$ and

For the long side, $A_s = \dfrac{2060000}{.875 \times 18000 \times 24} = 5.45\square''$. Requiring 28 ½φ 10′-0″, with Σ_0 of 44.0□″.

For the short side, $A_s = \dfrac{2475000}{.875 \times 18000 \times 24} = 6.55\square''$. Requiring 34 ½φ 9′-0″, with Σ_0 of 53.4□″.

These bars should be equally spaced within the effective width, as described before, and two additional bars should be furnished in each direction, placed outside the effective width.

Bond may be computed by using co-efficient K_4. The values of the ratios of e/l and c/s already found, when traced to their intersections on the graph for K_4, as described above, give values of K_4 of .26 and .213 respectively.

The formula for external shear for bond is, $V = K_4P$ and $u = \dfrac{V}{\Sigma_0 jd}$. Therefore, the shear along the long side of column is .26 × 350000 = 91000#, and along short side, .213 × 350000 = 74500#.

For the long side, $u = \dfrac{91000}{53.4 \times .875 \times 24} = 81$ #/□″.

For the short side, $u = \dfrac{74500}{44.0 \times .875 \times 24} = 81$ #/□″.

These bond stresses are slightly high for straight deformed bars, which are limited to 75 #/□″ for 2000 lb. concrete, and low for hooked bars, which permit 150 #/□″. If straight bars are used, their number should be increased by the ratio of 81/75.

It must be noted that the shear along the long side should be used in connection with the steel running at right angles to it, and similarly for the short side.

Diagonal tension may be computed by means of co-efficient K_4. The formula is, $v = \dfrac{K_4P}{(c+2d)\ jd}$. Values of K_4 are found from curve Page 80 by using proper ratios of $\dfrac{e+2d}{l}$ and $\dfrac{c+2d}{s}$. These ratios will be found to be $\dfrac{84}{126} = .67$, long side, and $\dfrac{70}{114} = .61$, short side. Curve gives K_4 values of 0.17 for long side, and by transposition 0.14 for short side. Then

For the long side, $v = \dfrac{0.17 \times 350000}{(36+48) \times .875 \times 24} = 33.8$ lbs. sq. in.

For the short side, $v = \dfrac{0.14 \times 350000}{(22+48) \times .875 \times 24} = 33.4$ lbs. sq. in.

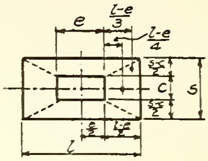
These are satisfactory for straight bars (allowable $v = 40$ lbs. sq. in.)

RECTANGULAR COLUMN FOOTINGS

DESIGN CO-EFFICIENTS

$K_3 = \frac{1}{2}\left(1-\frac{e}{l}\,\frac{c}{s}\right)$

$K_4 = \frac{1}{4}\left(1+\frac{e}{l}\right)\left(1-\frac{c}{s}\right)$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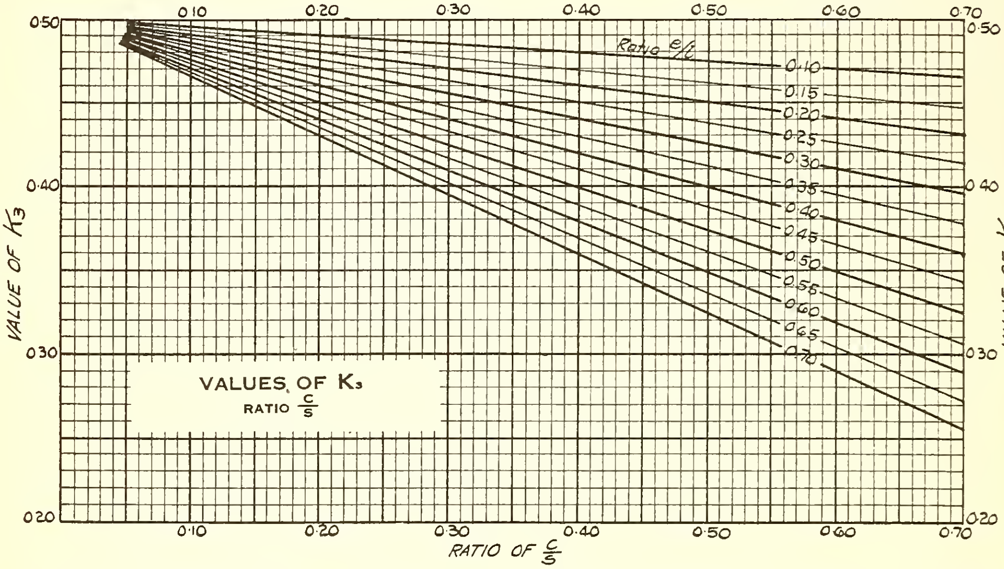
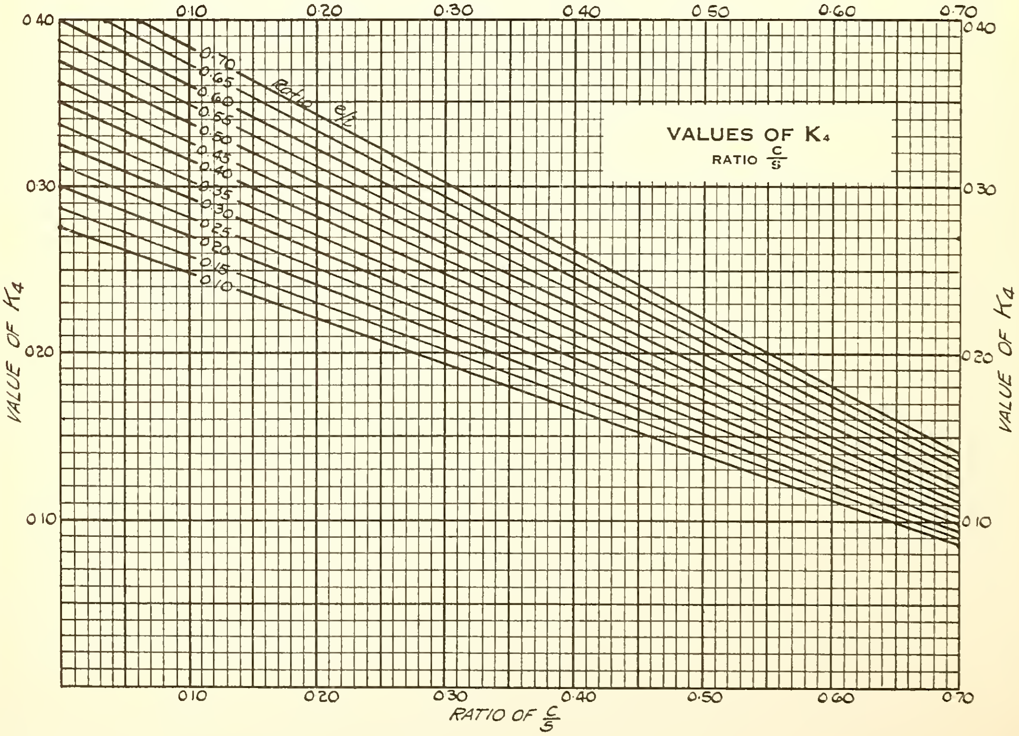




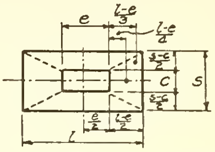
RECTANGULAR COLUMN FOOTINGS

DESIGN CO-EFFICIENTS

$K_5 = \frac{1}{24}\left(1-\frac{e}{l}\right)^2\left(2+\frac{c}{s}\right)$

VALUES OF K5

RATIO $\frac{c}{s}$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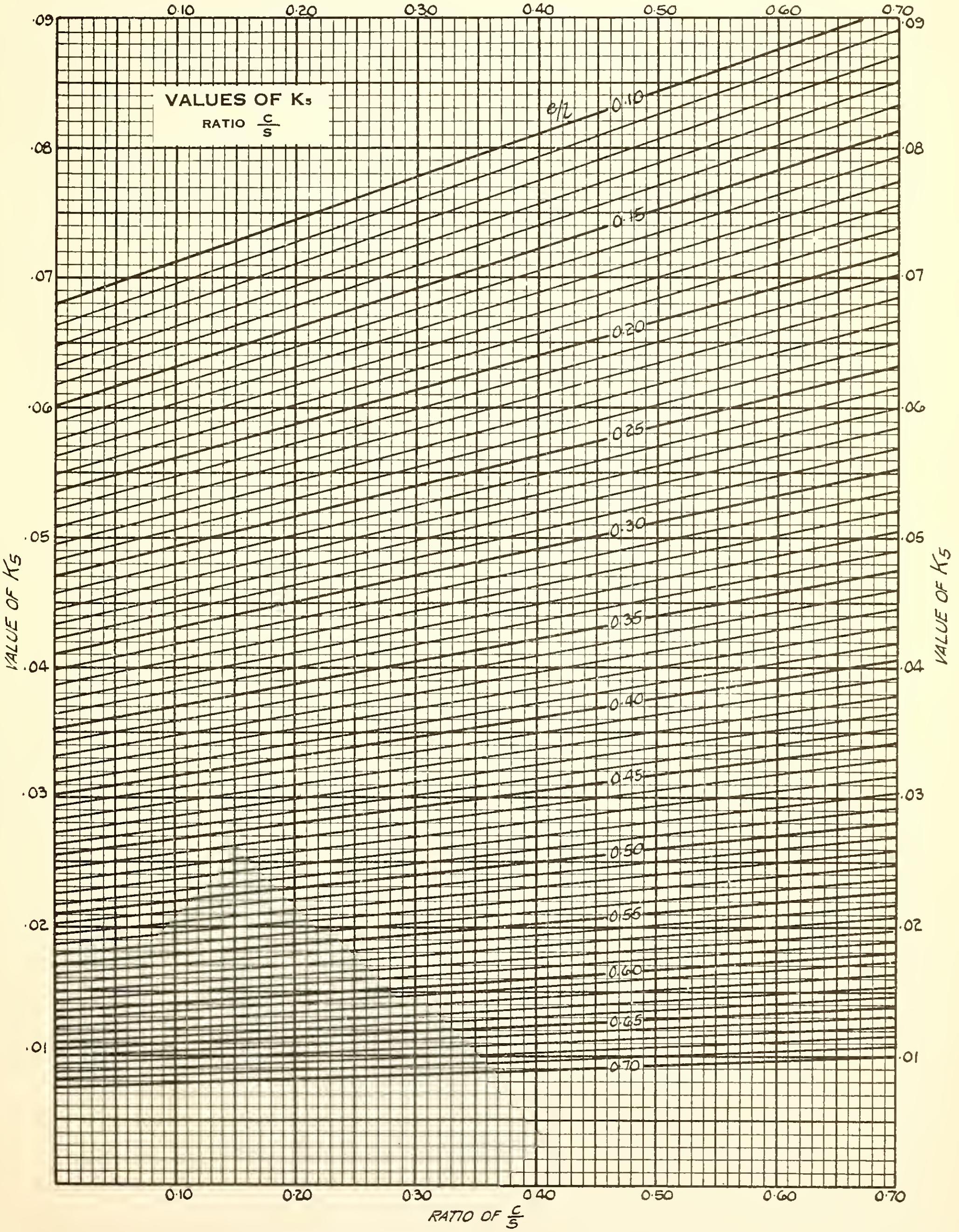
$\frac{l-e}{2}$
l



RECTANGULAR COLUMN FOOTINGS

DESIGN DATA

$$K_3 = \frac{1}{2}\left(1 - \frac{e}{l}\,\frac{c}{s}\right)$$

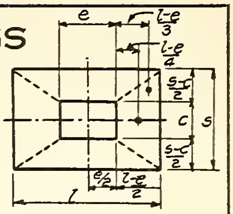
$$K_4 = \frac{1}{4}\left(1 + \frac{e}{l}\right)\left(1 - \frac{c}{s}\right)$$

$$K_5 = \frac{1}{24}\left(1 - \frac{e}{l}\right)^2\left(2 + \frac{c}{s}\right)$$

$$K_6 = \frac{\frac{c}{e_1}\left(\frac{e}{e_1} - \frac{c}{e_1}\right) + 1}{2\left(1 + \frac{e}{e_1} - \frac{c}{e_1}\right)}$$

$$d = \text{Eff. Depth} = K_3\frac{P}{(c + e)\,v} \qquad A_s = \frac{K_5Pl}{jdf_s} \qquad u = \frac{K_4P}{\Sigma_0 jd}$$

$$v = \frac{K_4P}{(c + 2d)\,jd}$$



VALUES OF K3

$\frac{e}{l}$	Values of $\frac{c}{s}$												
	.10	.15	.20	.25	.30	.35	.40	.45	.50	.55	.60	.65	.70
0.10	.49	.49	.49	.49	.48	.48	.48	.48	.47	.47	.47	.47	.46
.15	.49	.49	.48	.48	.48	.47	.47	.47	.46	.46	.45	.45	.45
.20	.49	.48	.48	.47	.47	.46	.46	.45	.45	.44	.44	.43	.43
.25	.49	.48	.47	.47	.46	.46	.45	.44	.44	.43	.42	.42	.41
.30	.48	.48	.47	.46	.45	.45	.44	.43	.42	.42	.41	.40	.39
.35	.48	.47	.46	.46	.45	.44	.43	.42	.41	.40	.39	.39	.38
.40	.48	.47	.46	.45	.44	.43	.42	.41	.40	.39	.38	.37	.36
.45	.48	.47	.45	.44	.43	.42	.41	.40	.39	.38	.36	.35	.34
.50	.47	.46	.45	.44	.42	.41	.40	.39	.37	.36	.35	.34	.32
.55	.47	.46	.44	.43	.42	.40	.39	.38	.36	.35	.33	.32	.31
.60	.47	.45	.44	.42	.41	.39	.38	.36	.35	.33	.32	.30	.29
.65	.47	.45	.43	.42	.40	.39	.37	.35	.34	.32	.30	.29	.27
.70	.46	.45	.43	.41	.39	.38	.36	.34	.32	.31	.29	.27	.25

VALUES OF K5

$\frac{e}{l}$	Values of $\frac{c}{s}$								
	.10	.15	.20	.25	.30	.35	.40	.45	.50
0.10	.071	.073	.074	.076	.078	.079	.081	.083	.085
.15	.063	.065	.066	.068	.069	.071	.072	.074	.075
.20	.056	.057	.059	.060	.061	.063	.064	.065	.067
.25	.049	.050	.052	.053	.054	.055	.056	.057	.059
.30	.043	.044	.045	.046	.047	.048	.049	.050	.051
.35	.037	.038	.039	.040	.041	.041	.042	.043	.044
.40	.032	.032	.033	.034	.035	.035	.036	.037	.038
.45	.027	.027	.028	.028	.029	.030	.030	.031	.032
.50	.022	.022	.023	.024	.024	.024	.025	.026	.026
.55	.018	.018	.019	.019	.019	.020	.020	.021	.021
.60	.014	.014	.015	.015	.015	.016	.016	.016	.017
.65	.011	.011	.011	.012	.012	.012	.012	.013	.013
.70	.008	.008	.008	.008	.009	.009	.009	.009	.009

VALUES OF K4

$\frac{e}{l}$	Values of $\frac{c}{s}$												
	.10	.15	.20	.25	.30	.35	.40	.45	.50	.55	.60	.65	.70
0.10	.25	.23	.22	.20	.19	.18	.16	.15	.14	.12	.11	.09	.08
.15	.26	.24	.23	.21	.20	.19	.17	.16	.14	.13	.11	.10	.08
.20	.27	.25	.24	.22	.21	.19	.18	.16	.15	.13	.12	.10	.09
.25	.28	.26	.25	.23	.22	.20	.19	.17	.15	.14	.12	.11	.09
.30	.29	.27	.26	.24	.23	.21	.19	.18	.16	.14	.13	.11	.10
.35	.30	.29	.27	.25	.24	.22	.20	.19	.17	.15	.13	.12	.10
.40	.31	.30	.28	.26	.24	.23	.21	.20	.17	.16	.14	.12	.10
.45	.33	.31	.29	.27	.25	.23	.22	.20	.18	.16	.14	.13	.11
.50	.34	.32	.30	.28	.26	.24	.22	.21	.19	.17	.15	.13	.11
.55	.35	.33	.31	.29	.27	.25	.23	.22	.19	.17	.15	.13	.11
.60	.36	.34	.32	.30	.28	.26	.24	.22	.20	.18	.16	.14	.12
.65	.37	.35	.33	.31	.29	.27	.25	.23	.20	.18	.16	.14	.12
.70	.38	.36	.34	.32	.30	.27	.25	.23	.21	.19	.17	.15	.13

VALUES OF K6

$\frac{e}{e_1}$	Values of $\frac{c}{e_1}$								
	.20	.25	.30	.35	.40	.45	.50	.55	.60
0.2	.433	.451	.468	.484					
0.4	.385	.403	.419	.434	.450	.464	.477	.489	
0.6	.350	.367	.383	.399	.414	.428	.442	.454	.466
0.8	.322	.339	.356	.372	.387	.402	.416	.430	.443
1.0	.300	.317	.334	.350	.366	.382	.397	.411	.425
1.2	.282	.299	.316	.333	.350	.366	.381	.396	.411
1.4	.266	.284	.302	.319	.336	.352	.369	.384	.400
1.6	.253	.272	.290	.307	.325	.342	.358	.375	.390
1.8	.242	.261	.279	.297	.315	.332	.350	.366	.383
2.0	.233	.252	.270	.289	.307	.325	.342	.359	.377
2.4	.225	.244	.263	.281	.300	.318	.336	.353	.371
2.6	.217	.237	.256	.275	.293	.312	.330	.348	.366
2.8	.211	.230	.250	.269	.288	.307	.325	.344	.362

SIZES IN FEET AND INCHES

ECONOMICAL SIZE RECTANGULAR FOOTINGS

AREA SQ. FT.	Values of $e-c$																							
	2"		4"		6"		8"		10"		12"		14"		16"		18"		20"		22"		24"	
	l	s	l	s	l	s	l	s	l	s	l	s	l	s	l	s	l	s	l	s	l	s	l	s
5	2-4	2-2	2-5	2-1	2-6	2-0	2-7	1-11	2-8	1-10	2-9	1-10	2-11	1-9	3-0	1-8	3-1	1-8	3-3	1-7	3-4	1-6	3-5	1-5
10	3-3	3-1	3-4	3-0	3-5	2-11	3-6	2-10	3-7	2-10	3-8	2-9	3-10	2-8	3-11	2-7	4-0	2-6	4-1	2-6	4-3	2-5	4-4	2-4
15	3-11	3-10	4-1	3-8	4-2	3-8	4-3	3-7	4-4	3-6	4-5	3-5	4-6	3-4	4-7	3-3	4-9	3-2	4-10	3-2	4-11	3-1	5-0	3-0
20	4-7	4-5	4-8	4-4	4-9	4-3	4-10	4-2	4-11	4-1	5-0	4-0	5-1	3-11	5-2	3-10	5-3	3-10	5-5	3-9	5-6	3-8	5-7	3-7
25	5-1	4-11	5-2	4-10	5-3	4-9	5-4	4-9	5-5	4-8	5-6	4-7	5-7	4-6	5-9	4-5	5-10	4-4	5-11	4-3	6-0	4-2	6-1	4-2
30	5-7	5-5	5-8	5-4	5-9	5-3	5-10	5-2	5-11	5-1	6-0	5-0	6-1	4-11	6-2	4-10	6-3	4-10	6-4	4-9	6-6	4-8	6-7	4-7
35	6-0	5-10	6-1	5-9	6-2	5-8	6-3	5-7	6-4	5-6	6-5	5-6	6-6	5-5	6-7	5-4	6-9	5-3	6-10	5-2	6-11	5-1	7-0	5-0
40	6-5	6-3	6-6	6-2	6-7	6-1	6-8	6-0	6-9	6-0	6-10	5-11	6-11	5-10	7-0	5-9	7-1	5-8	7-3	5-7	7-4	5-6	7-5	5-5
45	6-9	6-8	6-10	6-7	7-0	6-6	7-1	6-5	7-2	6-4	7-3	6-3	7-4	6-2	7-5	6-1	7-6	6-0	7-7	5-11	7-8	5-11	7-9	5-10
50	7-2	7-0	7-3	6-11	7-4	6-10	7-5	6-9	7-6	6-8	7-7	6-7	7-8	6-6	7-9	6-6	7-10	6-5	8-0	6-3	8-1	6-2	8-2	6-2
55	7-6	7-4	7-7	7-3	7-8	7-2	7-9	7-1	7-10	7-1	7-11	7-0	8-0	6-11	8-1	6-10	8-2	6-9	8-4	6-8	8-5	6-7	8-6	6-6
60	7-10	7-8	7-11	7-7	8-0	7-6	8-1	7-5	8-2	7-4	8-3	7-4	8-4	7-3	8-5	7-2	8-6	7-1	8-7	7-0	8-9	6-11	8-10	6-10
65	8-2	8-0	8-3	7-11	8-4	7-10	8-5	7-9	8-6	7-8	8-7	7-7	8-8	7-6	8-9	7-5	8-10	7-4	8-11	7-3	9-0	7-3	9-1	7-2
70	8-5	8-4	8-6	8-3	8-7	8-2	8-8	8-1	8-10	8-0	8-11	7-11	9-0	7-10	9-1	7-9	9-2	7-8	9-3	7-7	9-4	7-6	9-6	7-5
75	8-9	8-7	8-10	8-6	8-11	8-5	9-0	8-4	9-1	8-3	9-2	8-2	9-3	8-1	9-4	8-1	9-5	8-0	9-6	7-11	9-8	7-9	9-10	7-8
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160	12-9	12-7	12-10	12-6	12-11	12-5	13-0	12-4	13-1	12-3	13-2	12-2	13-3	12-1	13-4	12-0	13-5	11-11	13-6	11-10	13-7	11-10	13-8	11-9
170	13-1	13-0	13-2	12-11	13-3	12-10	13-5	12-9	13-6	12-8	13-7	12-7	13-8	12-6	13-9	12-5	13-10	12-4	13-11	12-3	14-0	12-2	14-1	12-1
180	13-6	13-4	13-7	13-3	13-8	13-2	13-9	13-1	13-10	13-0	13-11	13-0	14-0	12-11	14-1	12-10	14-2	12-9	14-3	12-8	14-4	12-7	14-5	12-6
190	13-10	13-9	13-11	13-8	14-0	13-7	14-1	13-6	14-2	13-5	14-4	13-4	14-5	13-3	14-6	13-2	14-7	13-1	14-8	13-0	14-9	12-11	14-10	12-10
200	14-3	14-1	14-4	14-0	14-5	13-11	14-6	13-10	14-7	13-9	14-8	13-8	14-9	13-7	14-10	13-6	14-11	13-5	15-0	13-4	15-1	13-3	15-2	13-2

GENERAL NOTES ON COLUMN FOOTINGS

Design:

In the method of design of footings as used herein, the reinforcing bars are placed in two directions, parallel to the sides of the footing.

The bars for moment or bond are to be equally spaced within the effective width of the footing. This effective width is the sum of the width of column or pedestal, plus twice the effective depth of the footing plus half of the remaining distance to the edge of the footing. Additional steel should be placed outside of this effective width, preferably at a spacing equal to twice the spacing of the effective steel, but in no case shall less than one extra bar be provided along each side.

Bars should be about 6″ shorter than the length of footing in the direction considered.

A minimum of 4″ should be added to the effective depth, below the center of steel.

Compressive stresses in footings are generally quite small. If it seems advisable to compute them, the effective width as determined for reinforcing, above, should be used as the width of beam in computations for slab type footings. In stepped footings the widths of the blocks should be taken as the width of beam. Regular beam formulae may be used for the width of "b" as found, or the steel ratio "p" may be found and the compressive stress determined from it. In stepped footings the area of concrete equals the effective depth multiplied by the width of block considered.

The methods presented by Messrs. Taylor, Thompson and Smulski in "Concrete, Plain and Reinforced", are used as a basis for the preparation of material on footings in this book.

The values of K_1 on pages 76 and 77 are given direct for all combinations of column and footing width. This greatly simplifies the calculation of bond and diagonal tension stresses.

The upper and lower blocks of stepped footings should be poured monolithic.

In the Universal Footing Tables a fiber stress of 18,000 lbs. per sq. in. was used for the moment steel. Other stresses may be used in direct ratio. Thus,

For $f_s = 16{,}000$ multiply given A_s by 1.125.

For $f_s = 20{,}000$ multiply given A_s by 0.90.

Bearing Power of Soils:

The question of allowable soil pressures for use in footing design is a most important one. The following permissable bearing values are in line with good practice.

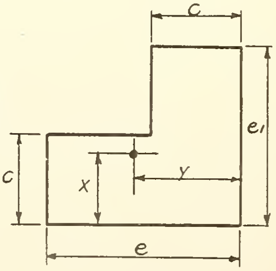
Solid ledge rock, 20% of ultimate crushing strength, with maximum of	100 tons per sq. ft.
Shale and hardpan	10 tons per sq. ft.
Gravel, compact sand, and hard yellow clay	6 tons per sq. ft.
Coarse sand, hard blue clay, or these two mixed, disintegrated ledge rock	5 tons per sq. ft.
Plastic clay, mixed or unmixed with sand, or fine grained dry sand	4 tons per sq. ft.
Fine grained wet sand, confined	3 tons per sq. ft.
Ordinary clay and sand	2 tons per sq. ft.
Soft clay, sandy loam, or silt	1 ton per sq. ft.

L-Shape Corner Columns:

The corner columns of a building are occasionally made L-shaped. When this is done, the center of gravity of the column section must coincide with the center of the footing. The tabulated values of K_6 simplify the calculation of the c. g. of the column.

The formula is: $x = \dfrac{ec + e_1^2 - c^2}{2(e + e_1 - c)}$

By the use of the co-efficient, K_6, the distance "x" $= K_6 e_1$, and by interchanging "e" with "e_1", $y = K_6 e$.



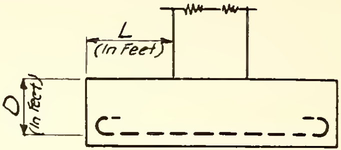
C.G. L-Shaped Column

WALL FOOTINGS

PLAIN AND REINFORCED CONCRETE

Conditions:

$v = .02\,f'_c$ S = Soil pressure per sq. ft.
$u = .10\,f'_c$ A_s = Area steel per foot length.
$j = .875$ D = Effective depth—reinf. footing.
$f_s = 18000$ D' = Total depth—plain footing.
$f_c = .03\,f'_c$



Reinforced Footings:

$D = K_D L$
$A_s = K_s L$

$$K_D = \frac{S}{2.52\,f'_c + S}$$

$$K_s = \frac{S}{31500 \times K_D}$$

$$\Sigma_0 = \frac{S}{1.05\,f'_c K_D}$$

Plain Footings:

$D' = K'_D L$ = Total depth.

$$K'_D = \sqrt{\frac{S}{48\,f_c}} = \sqrt{\frac{S}{1.44\,f'_c}}$$

S	f′c = 2000 lbs. sq. in.				f′c = 2500 lbs. sq. in.				f′c = 3000 lbs. sq. in.			
	K'_D	K_D	K_s	Σ_0	K'_D	K_D	K_s	Σ_0	K'_D	K_D	K_s	Σ_0
2000	.84	.284	.224	3.35	.75	.241	.264	3.16	.68	.209	.304	3.04
2500	.93	.332	.239	3.59	.83	.284	.280	3.35	.76	.248	.320	3.20
3000	1.02	.373	.256	3.83	.91	.323	.295	3.54	.83	.284	.336	3.35
3500	1.10	.410	.271	4.06	.99	.357	.311	3.73	.90	.317	.351	3.50
4000	1.18	.443	.287	4.30	1.06	.388	.327	3.92	.96	.346	.369	3.66
4500	1.25	.472	.302	4.54	1.12	4.16	.343	4.11	1.02	.374	.382	3.82
5000	1.32	.498	.319	4.78	1.18	.442	.359	4.31	1.08	.398	.399	3.98
5500	1.38	.521	.335	5.02	1.24	.466	.375	4.50	1.13	.421	.415	4.14
6000	1.44	.543	.351	5.26	1.29	.488	.390	4.69	1.18	.443	.431	4.30
6500	1.50	.563	.367	5.50	1.35	.508	.406	4.88	1.23	.462	.446	4.46
7000	1.56	.581	.382	5.74	1.40	.526	.422	5.07	1.28	.481	.462	4.62
8000	1.66	.613	.415	6.22	1.49	.560	.454	5.45	1.36	.515	.494	4.94
9000	1.77	.640	.447	6.70	1.58	.589	.486	5.83	1.44	.544	.526	5.25
10000	1.87	.665	.478	7.18	1.67	.613	.518	6.21	1.52	.570	.558	5.57

Example:

Given a 12″ wall with a uniformly distributed load of 12000# per lineal foot. Soil pressure (S) = 3000# sq. ft.; 2000 lb. concrete.

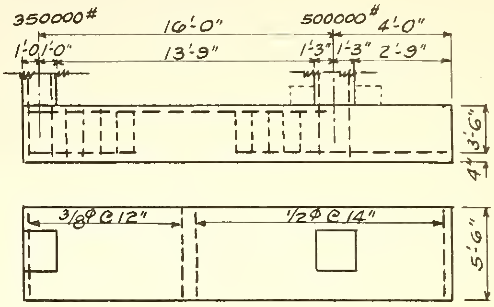
Disregarding weight of footing, the required width will be $\frac{12000}{3000} = 4.0'$.

The distant "L" will be $\frac{4.0 - 1.0}{2} = 1.5'$.

Constants in Table are: for $S = 3000$ and $f'_c = 2000$; $K_D = .373$; $K_s = .256$; $\Sigma_0 = 3.83$.

Then $D = .373 \times 1.5 = .56$ feet (or 6¾″). With 4″ protection under bars this would give a total theoretical depth of 10¾″. Actually, the footing would probably be made 12″ deep, with an effective depth of 8″. The value of A_s would then be in the ratio of $\frac{6.75}{8.00} \times .256 \times 1.5 = 3.24$□″ per ft. (⅜ϕ @ 4″ or ½ϕ @ 7″.) For bond, with 8″ eff. depth the required $\Sigma_0 = \frac{6.75}{8.00} \times 3.83 = 3.24$; 3-⅜ϕ bars give $\Sigma_0 = 3 \times 1.18 = 3.54$; ½ϕ @ 7″ give value of $1.72 \times 1.57 = 2.7$. Use ⅜ϕ @ 4″ cts.

COMBINED FOOTINGS



Typical Example:

Assume 24x36 wall column, with load of 350000 lbs.

Assume 30x30 interior column, with load of 500000 lbs.

Soil pressure 8000 lbs. sq. ft.; column centers 16'-0".

Assume weight of footing = 60000 lbs. Then total load = 350000 + 500000 + 60000 = 910000#.

Required area = 910000 ÷ 8000 = 114 sq. ft.

Interior column produces bending about center line of wall column, of 16 × 500000 = 8,000,000 ft. lbs.

Distance from center of wall column to c. g. of footing = 8,000,000 ÷ (350000 + 500000) = 9.4'. This distance plus 1'-0" (center wall column to end of footing) = 10.4'. The total length of footing will then be 2 × 10.4' = 20.8'; say 21'-0".

Width will be 114 ÷ 21 = 5.43; say 5'-6".

Unit pressure is (350000 + 500000) ÷ (21.0 × 5.5) = 7360 lbs.

Pressure per lin. ft. = (350000 + 500000) ÷ 21 = 40500 lbs.

Moments:

Length of cantilever is 2'-9".

Bending moment in cantilever $= 40500 \times 2.75 \times \frac{2.75}{2} \times 12 = 1{,}840{,}000$ in. lbs.

Moment of inner face, interior column =

$$\frac{1}{16} w_1 l_1^2 = \frac{40500 \times 13.75^2}{16} \times 12 = 5{,}740{,}000 \text{ in. lbs.}$$

Point of zero shear is at $\frac{350000}{40500} = 8.65'$ from outer face of outer column, or $8.65 - 2.0 = 6.65'$ from inner face. The moment at this point is $40500 \times \frac{6.65^2}{2} \times 12 =$ 10,750,000 in. lbs. (Maximum.)

Shears:

External shear due to cantilever at outer edge of interior column is 40500 × 2.75 = 111500 lbs.

External shear at inner edge, interior column = 500000 — (40500 × 5.25) = 287000 lbs. (Maximum.)

External shear at inner edge wall column = 350000 — (40500 × 2) = 269000 lbs.

Depth of Footing:

Depth from diagonal tension: $d = \frac{287000}{66 \times 0.875 \times 120} = 41.5''$ (say 42").

Depth from bending moment: $d^2 = \frac{10{,}750{,}000}{66 \times 113.1} = 1440$ and "d" = 38".

(In the above, for $f_s = 18000$ and $f_c = 700$, $R = 113.1$.)

Depth for diagonal tension governs.

Longitudinal Reinforcing:

With $d = 42''$, from $A_s = \frac{M}{jdf_s}$:

At center of footing; $A_s = \frac{10{,}750{,}000}{.875 \times 42 \times 18000} = 16.25$ (27 — ⅞φ)

At interior column; $A_s = \frac{5{,}740{,}000}{.875 \times 42 \times 18000} = 8.7$ (28 — ⅝φ) Extend into cantilever.

At cantilever; $A_s = \frac{1{,}840{,}000}{.875 \times 42 \times 18000} = 2.8$ (From above)

Bond:

Top: With 100# allowable bond, required $\Sigma_0 = \frac{269000}{100 \times \frac{7}{8} \times 42} = 73$ in. at inner edge wall column. The perimeter of a ⅞φ bar is 2.75; for the 27 bars req'd for moment, $\Sigma_0 = 27 \times 2.75 = 74.2$ (OK).

Bottom: With bond as above, required $\Sigma_0 = \frac{287000}{100 \times \frac{7}{8} \times 42} = 78$ in., at inner edge of interior column. This requires 40-⅝φ bars, which is excessive; the number may be reduced to 28 by placing a 16" depth of block on top of footing under interior column, making $d = 58''$; extend bars.

Transverse Reinforcing:

Projection of footing, laterally, at interior column is 1'-6"; at wall column it is 1'-3".

At interior column, $M = 7360 \times 1.5 \times \frac{1.5}{2} \times 12 = 99400$ in. lbs.; $A_s = .15$ sq. in. = ½φ @ 14" cts.

At exterior column, $M = 7360 \times 1.25 \times \frac{.25}{2} \times 12 = 69000$ in. lbs.; $A_s = .104$ sq. in. = ⅜φ @ 12" cts.

STAIR DIMENSIONS

VARIOUS NUMBERS OF RISERS AND TREADS

*From Hool and Johnson's "Handbook of Building Construction". Published by McGraw-Hill.

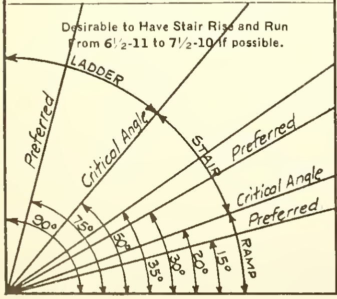
HEIGHTS OF VARIOUS NUMBERS OF RISERS, IN FEET

RISER HEIGHT	NUMBER OF RISERS																		
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
5	0-10	1-3	1-8	2-1	2-6	2-11	3-4	3-9	4-2	4-7	5-0	5-5	5-10	6-3	6-8	7-1	7-6	7-11	8-4
5¼	0-10½	1-3¾	1-9	2-2¼	2-7½	3-0¾	3-6	3-11¼	4-4½	4-9¾	5-3	5-8¼	6-1½	6-6¾	7-0	7-5¼	7-10½	8-3¾	8-9
5½	0-11	1-4½	1-10	2-3½	2-9	3-2½	3-8	4-1½	4-7	5-0½	5-6	5-11½	6-5	6-10½	7-4	7-9½	8-3	8-8½	9-2
5¾	0-11½	1-5¼	1-11	2-4¾	2-10½	3-4¼	3-10	4-3¾	4-9½	5-3¼	5-9	6-2¾	6-8½	7-2¼	7-8	8-1¾	8-7½	9-1¼	9-7
6	1-0	1-6	2-0	2-6	3-0	3-6	4-0	4-6	5-0	5-6	6-0	6-6	7-0	7-6	8-0	8-6	9-0	9-6	10-0
6¼	1-0½	1-6¾	2-1	2-7¼	3-1½	3-7¾	4-2	4-8¼	5-2½	5-8¾	6-3	6-9¼	7-3½	7-9¾	8-4	8-10¼	9-4½	9-10¾	10-5
6½	1-1	1-7½	2-2	2-8½	3-3	3-9½	4-4	4-10½	5-5	5-11½	6-6	7-0½	7-7	8-1½	8-8	9-2½	9-9	10-3½	10-10
6¾	1-1½	1-8¼	2-3	2-9¾	3-4½	3-11¼	4-6	5-0¾	5-7½	6-2¼	6-9	7-3¾	7-10½	8-5¼	9-0	9-6¾	10-1½	10-8¼	11-3
7	1-2	1-9	2-4	2-11	3-6	4-1	4-8	5-3	5-10	6-5	7-0	7-7	8-2	8-9	9-4	9-11	10-6	11-1	11-8
7⅛	1-2¼	1-9⅜	2-4½	2-11⅝	3-6¾	4-1⅞	4-9	5-4⅛	5-11¼	6-6⅜	7-1½	7-8⅝	8-3¾	8-10⅞	9-6	10-1⅛	10-8¼	11-3⅜	11-10½
7¼	1-2½	1-9¾	2-5	3-0¼	3-7½	4-2¾	4-10	5-5¼	6-0½	6-7¾	7-3	7-10¼	8-5½	9-0¾	9-8	10-3¼	10-10½	11-5¾	12-1
7⅜	1-2¾	1-10⅛	2-5½	3-0⅞	3-8¼	4-3⅝	4-11	5-6⅜	6-1¾	6-9⅛	7-4½	7-11⅞	8-7¼	9-2⅝	9-10	10-5⅜	11-0¾	11-8⅛	12-3½
7½	1-3	1-10½	2-6	3-1½	3-9	4-4½	5-0	5-7½	6-3	6-10½	7-6	8-1½	8-9	9-4½	10-0	10-7½	11-3	11-10½	12-6
7⅝	1-3¼	1-10⅞	2-6½	3-2⅛	3-9¾	4-5⅜	5-1	5-8⅝	6-4¼	6-11⅞	7-7½	8-3⅛	8-10¾	9-6⅜	10-2	10-9⅝	11-5¼	12-0⅞	12-8½
7¾	1-3½	1-11¼	2-7	3-2¾	3-10½	4-6¼	5-2	5-9¾	6-5½	7-1¼	7-9	8-4¾	9-0½	9-8¼	10-4	10-11¾	11-7½	12-3¼	12-11
7⅞	1-3¾	1-11⅝	2-7½	3-3⅜	3-11¼	4-7⅛	5-3	5-10⅞	6-6¾	7-2⅝	7-10½	8-6⅜	9-2¼	9-10⅛	10-6	11-1⅞	11-9¾	12-5⅝	13-1½
8	1-4	2-0	2-8	3-4	4-0	4-8	5-4	6-0	6-8	7-4	8-0	8-8	9-4	10-0	10-8	11-4	12-0	12-8	13-4
8⅛	1-4¼	2-0⅜	2-8½	3-4⅝	4-0¾	4-8⅞	5-5	6-1⅛	6-9¼	7-5⅜	8-1½	8-9⅝	9-5¾	10-1⅞	10-10	11-6⅛	12-2¼	12-10⅜	13-6½
8¼	1-4½	2-0¾	2-9	3-5¼	4-1½	4-9¾	5-6	6-2¼	6-10½	7-6¾	8-3	8-11¼	9-7½	10-3¾	11-0	11-8¼	12-4½	13-0¾	13-9
8⅜	1-4¾	2-1⅛	2-9½	3-5⅞	4-2¼	4-10⅝	5-7	6-3⅜	6-11¾	7-8⅛	8-4½	9-0⅞	9-9¼	10-5⅝	11-2	11-10⅜	12-6¾	13-3⅛	13-11½
8½	1-5	2-1½	2-10	3-6½	4-3	4-11½	5-8	6-4½	7-1	7-9½	8-6	9-2½	9-11	10-7½	11-4	12-0½	12-9	13-5½	14-2
8⅝	1-5¼	2-1⅞	2-10½	3-7⅛	4-3¾	5-0⅜	5-9	6-5⅝	7-2¼	7-10⅞	8-7½	9-4⅛	10-0¾	10-9⅜	11-6	12-2⅝	12-11¼	13-7⅞	14-4½
8¾	1-5½	2-2¼	2-11	3-7¾	4-4½	5-1¼	5-10	6-6¾	7-3½	8-0¼	8-9	9-5¾	10-2½	10-11¼	11-8	12-4¾	13-1½	13-10¼	14-7
8⅞	1-5¾	2-2⅝	2-11½	3-8⅜	4-5¼	5-2⅛	5-11	6-7⅞	7-4¾	8-1⅝	8-10½	9-7⅜	10-4¼	11-1⅛	11-10	12-6⅞	13-3¾	14-0⅝	14-9½
9	1-6	2-3	3-0	3-9	4-6	5-3	6-0	6-9	7-6	8-3	9-0	9-9	10-6	11-3	12-0	12-9	13-6	14-3	15-0

WIDTHS OF VARIOUS NUMBERS OF TREADS, IN FEET

TREAD WIDTH	NUMBER OF TREADS																		
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
9	1-6	2-3	3-0	3-9	4-6	5-3	6-0	6-9	7-6	8-3	9-0	9-9	10-6	11-3	12-0	12-9	13-6	14-3	15-0
9¼	1-6½	2-3¾	3-1	3-10¼	4-7½	5-4¾	6-2	6-11¼	7-8½	8-5¾	9-3	10-0¼	10-9½	11-6¾	12-4	13-1¼	13-10½	14-7¾	15-5
9½	1-7	2-4½	3-2	3-11½	4-9	5-6½	6-4	7-1½	7-11	8-8½	9-6	10-3½	11-1	11-10½	12-8	13-5½	14-3	15-0½	15-10
9¾	1-7½	2-5¼	3-3	4-0¾	4-10½	5-8¼	6-6	7-3¾	8-1½	8-11¼	9-9	10-6¾	11-4½	12-2¼	13-0	13-9¾	14-7½	15-5¼	16-3
10	1-8	2-6	3-4	4-2	5-0	5-10	6-8	7-6	8-4	9-2	10-0	10-10	11-8	12-6	13-4	14-2	15-0	15-10	16-8
10¼	1-8½	2-6¾	3-5	4-3¼	5-1½	5-11¾	6-10	7-8¼	8-6½	9-4¾	10-3	11-1¼	11-11½	12-9¾	13-8	14-6¼	15-4½	16-2¾	17-1
10½	1-9	2-7½	3-6	4-4½	5-3	6-1½	7-0	7-10½	8-9	9-7½	10-6	11-4½	12-3	13-1½	14-0	14-10½	15-9	16-7½	17-6
10¾	1-9½	2-8¼	3-7	4-5¾	5-4½	6-3¼	7-2	8-0¾	8-11½	9-10¼	10-9	11-7¾	12-6½	13-5¼	14-4	15-2¾	16-1½	17-0¼	17-11
11	1-10	2-9	3-8	4-7	5-6	6-5	7-4	8-3	9-2	10-1	11-0	11-11	12-10	13-9	14-8	15-7	16-6	17-5	18-4
11¼	1-10½	2-9¾	3-9	4-8¼	5-7½	6-6¾	7-6	8-5¼	9-4½	10-3¾	11-3	12-2¼	13-1½	14-0¾	15-0	15-11¼	16-10½	17-9¾	18-9
11½	1-11	2-10½	3-10	4-9½	5-9	6-8½	7-8	8-7½	9-7	10-6½	11-6	12-5½	13-5	14-4½	15-4	16-3½	17-3	18-2½	19-2
11¾	1-11½	2-11¼	3-11	4-10¾	5-10½	6-10¼	7-10	8-9¾	9-9½	10-9¼	11-9	12-8¾	13-8½	14-8¼	15-8	16-7¾	17-7½	18-7¼	19-7
12	2-0	3-0	4-0	5-0	6-0	7-0	8-0	9-0	10-0	11-0	12-0	13-0	14-0	15-0	16-0	17-0	18-0	19-0	20-0
12¼	2-0½	3-0¾	4-1	5-1¼	6-1½	7-1¾	8-2	9-2¼	10-2½	11-2¾	12-3	13-3¼	14-3½	15-3¾	16-4	17-4¼	18-4½	19-4¾	20-5
12½	2-1	3-1½	4-2	5-2½	6-3	7-3½	8-4	9-4½	10-5	11-5½	12-6	13-6½	14-7	15-7½	16-8	17-8½	18-9	19-9½	20-10
12¾	2-1½	3-2¼	4-3	5-3¾	6-4½	7-5¼	8-6	9-6¾	10-7½	11-8¼	12-9	13-9¾	14-10½	15-11¼	17-0	18-0¾	19-1½	20-2¼	21-3
13	2-2	3-3	4-4	5-5	6-6	7-7	8-8	9-9	10-10	11-11	13-0	14-1	15-2	16-3	17-4	18-5	19-6	20-7	21-8

*PITCH OF RAMPS, STAIRS, ETC.


Desirable to Have Stair Rise and Run From 6½-11 to 7½-10 if possible.

*POPULATION, VARIOUS TYPES OCCUPANCY

Rentable Floor Area Sq. Ft.	POPULATION PER FLOOR					
	Public Assem.	Schools, Ct. House	Stores	Factories	Offices	Hotels
3000	300	200	120	95	60	30
4000	400	267	160	125	80	40
5000	500	333	200	155	100	50
6000	600	400	240	185	120	60
7000	700	465	280	220	140	70
8000	800	535	320	250	160	80
9000	900	600	360	280	180	90
10000	1000	665	400	310	200	100
11000			440	345	220	110
12000			480	375	240	120
13000					260	130

*STAIRS FOR VARIOUS OCCUPANCIES

Rentable Floor Area Sq. Ft.	NUMBER AND WIDTH OF STAIRS				
	Schools	Stores	Factories	Offices	Hotels
3000	2-6'-6"	2-4'-6"	2-4'-0"	2-3'-6"	2-3'-6"
4000	3-6'-0"	2-5'-6"	2-4'-6"	2-3'-6"	2-3'-6"
5000	4-5'-6"	2-6'-6"	2-5'-0"	2-4'-0"	2-3'-6"
6000	4-6'-6"	3-5'-6"	3-4'-6"	2-4'-6"	2-3'-6"
7000	5-6'-6"	3-6'-0"	3-5'-0"	3-3'-6"	2-3'-6"
8000	5-6'-6"	3-6'-6"	4-4'-6"	3-4'-0"	2-3'-6"
9000	6-6'-6"	4-6'-0"	4-5'-0"	3-4'-6"	2-3'-6"
10000	7-6'-6"	4-6'-6"	4-5'-6"	4-4'-0"	2-4'-0"
11000		5-6'-0"	4-5'-6"	4-4'-0"	2-4'-0"
12000		5-6'-6"	4-6'-0"	4-4'-6"	3-3'-6"
13000				4-4'-6"	3-3'-6"

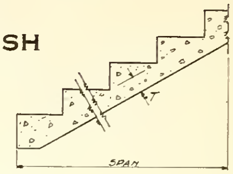
WEIGHTS OF CONCRETE STAIRS
PER
HORIZONTAL SQUARE FOOT

WEIGHTS INCLUDE CONCRETE, FINISH AND PLASTER SOFFIT, BUT NO LIVE LOAD

TYPE FINISH	RISE	TREAD	SLAB THICKNESS—INCHES																										
			3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10	10½	11	11½	12	12½	13	13½	14	14½	15	15½	16
MONOLITHIC	6	12	90	97	104	111	118	125	132	139	146	153	160	167	174	181	188	195	202	209	216	223	230	237	244	251	258	265	272
	6¼	11¾	92	99	106	114	121	128	135	142	149	157	164	171	178	185	192	198	206	213	220	227	234	241	248	256	263	270	277
	6½	11¼	96	102	110	117	125	131	139	146	154	160	168	175	182	189	197	204	212	218	225	232	239	247	254	261	268	275	283
	6¾	10¾	98	106	114	121	129	135	143	150	158	166	172	180	188	197	202	210	217	225	231	238	246	253	260	268	275	282	290
	7	10½	99	108	116	123	131	138	146	153	161	168	176	183	191	198	206	214	220	228	235	242	250	257	265	272	280	287	295
	7¼	10	104	113	121	128	136	140	151	158	167	174	182	190	198	205	212	221	228	236	244	252	259	267	275	283	290	298	306
	7½	9¾	107	116	123	130	139	146	155	163	170	178	186	194	202	210	218	225	234	241	250	258	266	274	282	289	297	305	313
	7¾	9½	110	119	126	134	143	151	159	167	175	183	191	198	207	215	224	232	239	248	256	264	272	280	288	296	304	313	321
	8	9	114	122	132	140	148	156	165	173	181	191	199	207	215	224	232	240	248	258	266	274	283	291	300	308	317	325	333
¾″ CEMENT	6	12	96	103	110	117	124	131	138	145	152	159	166	173	180	187	194	201	208	215	222	229	234	243	250	257	264	271	278
	6¼	11¾	98	105	113	120	127	134	141	148	156	163	170	177	184	192	199	205	212	219	226	233	240	247	254	262	269	276	283
	6½	11¼	102	109	116	124	131	138	145	153	160	166	174	181	189	194	203	210	218	224	232	239	247	254	261	268	275	282	290
	6¾	10¾	105	113	121	128	135	142	150	157	164	172	179	187	195	204	209	217	224	231	238	245	253	260	267	275	282	289	297
	7	10½	108	115	123	130	138	145	153	160	168	175	183	189	198	205	213	221	225	235	242	249	257	264	272	279	287	294	302
	7¼	10	112	120	128	136	143	151	158	166	174	181	190	197	205	213	219	228	235	240	251	259	266	274	282	290	297	305	313
	7½	9¾	114	123	130	138	147	154	162	170	177	186	192	202	209	218	225	233	241	249	256	264	272	280	288	295	303	311	319
	7¾	9½	118	126	134	142	151	158	167	174	182	191	199	206	215	223	232	239	246	256	264	272	280	288	296	304	312	321	329
	8	9	122	133	140	148	156	164	173	182	189	199	206	215	223	232	240	248	256	266	273	281	290	298	307	315	324	332	340
1½″ TERRAZZO	6	12	110	117	124	131	138	145	152	159	166	173	180	187	194	201	208	215	222	229	236	243	250	257	264	271	278	285	292
	6¼	11¾	113	120	127	134	141	148	156	163	170	177	184	191	199	206	213	219	226	234	241	248	255	262	269	277	284	291	298
	6½	11¼	117	124	131	139	146	152	160	168	175	181	189	196	204	210	218	225	232	239	246	253	261	268	275	282	289	296	304
	6¾	10¾	121	129	136	143	151	157	166	173	180	188	195	202	210	219	225	232	239	247	254	261	269	276	283	291	298	305	313
	7	10½	123	131	140	146	154	161	169	176	184	191	199	206	214	221	228	236	243	251	258	265	273	280	288	295	303	310	318
	7¼	10	128	137	145	152	160	168	175	182	191	198	206	214	222	229	236	245	252	260	268	276	283	291	299	307	314	322	329
	7½	9¾	132	140	148	155	164	171	180	187	195	203	210	219	226	235	243	250	258	266	273	281	289	297	305	312	320	328	336
	7¾	9½	135	144	152	159	168	176	185	192	200	208	216	224	233	240	249	257	264	273	281	289	297	305	313	321	329	338	346
	8	9	141	149	159	167	175	183	192	200	208	217	225	234	241	251	259	267	275	285	292	300	309	317	326	334	342	351	359
1½″ MARBLE	6	12	116	123	130	137	144	151	158	165	172	179	186	193	200	207	214	221	228	235	242	249	256	263	270	277	284	291	298
	6¼	11¾	119	126	133	140	147	155	162	169	176	183	191	198	205	212	219	225	232	240	247	254	261	268	275	283	290	297	304
	6½	11¼	124	130	138	145	153	158	166	174	181	188	195	203	210	216	224	228	239	245	253	264	268	275	282	289	296	303	311
	6¾	10¾	127	136	143	150	158	164	173	179	187	195	201	209	217	226	232	238	246	254	260	267	275	282	289	297	304	311	319
	7	10½	130	138	146	153	161	168	176	183	191	198	206	213	220	231	235	243	250	258	265	272	280	287	295	302	310	317	325
	7¼	10	136	144	152	160	167	175	182	189	199	205	214	221	229	236	244	252	259	268	275	283	290	298	306	314	321	329	337
	7½	9¾	139	148	155	163	171	178	187	194	202	210	218	226	234	242	250	258	266	273	281	289	297	305	313	320	328	336	344
	7¾	9½	143	152	160	167	176	183	192	200	208	216	224	232	240	248	257	264	272	281	288	296	304	312	320	328	336	345	353
	8	9	149	158	167	175	183	191	200	208	216	227	235	242	249	259	267	275	282	292	300	308	317	325	334	342	351	359	367

CONCRETE STAIR SLABS

VARIOUS SPANS, LIVE LOADS, AND FINISH



T = Slab thickness, inches
f_c = 800 lbs. sq. in.
f_s = 20,000 lbs. sq. in.
n = 15
All reinforcing bars round, 1″ from center of steel to bottom of slab.

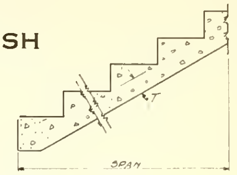
Figures in columns denoted "Reinf." are size and spacing of bars

FINISH	SPAN, FEET	60 lb. Live Load				80 lb. Live Load				100 lb. Live Load				120 lb. Live Load			
		RATIO, RISE TO TREAD				RATIO, RISE TO TREAD				RATIO, RISE TO TREAD				RATIO, RISE TO TREAD			
		6 x 12 6¼ x 11¾ 6½ x 11¼ 6¾ x 10¾ 7 x 10½		7¼ x 10 7½ x 9¾ 7¾ x 9½ 8 x 9		6 x 12 6¼ x 11¾ 6½ x 11¼ 6¾ x 10¾ 7 x 10½		7¼ x 10 7½ x 9¾ 7¾ x 9½ 8 x 9		6 x 12 6¼ x 11¾ 6½ x 11¼ 6¾ x 10¾ 7 x 10½		7¼ x 10 7½ x 9¾ 7¾ x 9½ 8 x 9		6 x 12 6¼ x 11¾ 6½ x 11¼ 6¾ x 10¾ 7 x 10½		7¼ x 10 7½ x 9¾ 7¾ x 9½ 8 x 9	
		T.	REINF.	T.	REINF.	T.	REINF.	T.	REINF.	T.	REINF.	T.	REINF.	T.	REINF.	T.	REINF.
MONOLITHIC	4	3	⅜-12	3	⅜-11	3	⅜-10	3	⅜-10	3	⅜-9	3	⅜-9	3	⅜-8	3	⅜-8
	5	3½	9	3½	8	3½	8	3½	7	3½	7	3½	6½	3½	6	3½	6
	6	4	7	4	7	4	6	4	6	4	6	4	5½	4	5½	4	½-9
	7	4½	5½	4½	½-9	4½	½-9	4½	½-9	4½	½-9	4½	½-8	4½	½-8	4½	7½
	8	5	½-9	5	8	5	8	5	7½	5	7	5	7	5	6½	5½	7
	9	5½	8	5½	7	5½	7	5½	6½	5½	6	5½	6	5½	6	6	6
	10	6	6½	6	6	6	6	6	5½	6	5½	6	⅝-8	6	⅝-8	6½	⅝-8
	11	6½	6	6½	5½	6½	5½	6½	⅝-8	6½	⅝-7½	7	7½	7	7½	7	7
	12	7	⅝-8	7	⅝-7½	7	⅝-7	7	7	7	7	7½	6½	7½	6½	8	6½
	13	7½	7	7½	6½	7½	6½	8	6	8	6	8	6	8	6	8½	6
	14	8	6	8	6	8	6	8½	5½	8½	5½	9	5½	8½	5½	9	5½
	15	8½	¾-8	9	5½	8½	5½	9	¾-7½	9	¾-7½	9½	¾-7	9½	¾-7	10	¾-6½
	16	9	7½	9½	¾-7	9½	¾-7	10	6½	9½	6½	10	6½	10	6½	10½	6
	17	9½	7	10	6½	10	6½	10½	6	10½	6	11	6	11	6	11½	5½
	18	10½	6½	11	6	11	6	11½	5½	11	5½	11½	5½	11½	5½	12	⅞-7½
	19	11	6	11½	5½	11½	5½	12	⅞-7½	12	⅞-7½	12½	⅞-7	12	⅞-7	13	7
	20	12	5½	12½	⅞-7	12	⅞-7	13	7	12½	7	13½	6½	13	6½	14	6
¾″ CEMENT	4	3	⅜-12	3	⅜-11	3	⅜-10	3	⅜-9	3	⅜-9	3	⅜-9	3	⅜-8	3	⅜-8
	5	3½	9	3½	8	3½	8	3½	7	3½	7	3½	6	3½	6	3½	5½
	6	4	6	4	6	4	6	4	6	4	5½	4	5½	4	½-9	4	½-9
	7	4½	5½	4½	½-9	4½	½-9	4½	½-8	4½	½-8	4½	½-8	4½	7½	5	8
	8	5	½-9	5	8	5	8	5	7	5	7	5	6½	5	6½	5½	7
	9	5½	7½	5½	6½	5½	6½	5½	6½	5½	6	5½	5½	5½	5½	6	6
	10	6	6½	6	6	6	6	6	5½	6	5½	6½	⅝-8	6½	⅝-8	6½	⅝-8
	11	6½	5½	6½	⅝-8	6½	⅝-8	6½	⅝-7½	6½	⅝-7½	7	7	7	7	7	7
	12	7	⅝-8	7	7	7	7	7½	6½	7½	7	7½	6½	7½	6	8	6½
	13	7½	7	7½	6½	7½	6½	8	6	8	6½	8	6	8	5½	8½	5½
	14	8	6	8½	6	8	6	8½	5½	8½	5½	9	5½	9	¾-8	9	¾-7
	15	8½	5½	9	5½	9	5½	9½	¾-7	9	¾-7½	9½	¾-7	9½	7	10	6½
	16	9	¾-7½	9½	¾-7	9½	¾-7	10	6½	10	6½	10½	6½	10	6½	10½	6
	17	9½	7	10½	6½	10	6½	10½	6	10½	6	11	6	11	6	11½	5½
	18	10½	6½	11	6	11	6	11½	⅞-7½	11½	5½	12	5½	12	5½	12	⅞-7
	19	11½	6	12	5½	12	5½	12	7	12½	⅞-7½	12½	⅞-7	13	⅞-7½	13	6½
	20	12½	5½	13	⅞-7	13	⅞-7½	13	6½	13	7	13½	6½	13½	6½	14	6

CONCRETE STAIR SLABS

VARIOUS SPANS, LIVE LOADS, AND FINISH

T = Slab thickness, inches
f_c = 800 lbs. sq. in.
f_s = 20,000 lbs. sq. in.
n = 15
All reinforcing bars round, 1″ from center of steel to bottom of slab.



Figures in columns denoted "Reinf." are size and spacing of bars

FINISH	SPAN, FEET	60 lb. Live Load				80 lb. Live Load				100 lb. Live Load				120 lb. Live Load			
		RATIO, RISE TO TREAD				RATIO, RISE TO TREAD				RATIO, RISE TO TREAD				RATIO, RISE TO TREAD			
		6 x 12 6¼ x 11¾ 6½ x 11¼ 6¾ x 10¾ 7 x 10½		7¼ x 10 7½ x 9¾ 7¾ x 9½ 8 x 9		6 x 12 6¼ x 11¾ 6½ x 11¼ 6¾ x 10¾ 7 x 10½		7¼ x 10 7½ x 9¾ 7¾ x 9½ 8 x 9		6 x 12 6¼ x 11¾ 6½ x 11¼ 6¾ x 10¾ 7 x 10½		7¼ x 10 7½ x 9¾ 7¾ x 9½ 8 x 9		6 x 12 6¼ x 11¾ 6½ x 11¼ 6¾ x 10¾ 7 x 10½		7¼ x 10 7½ x 9¾ 7¾ x 9½ 8 x 9	
		T.	REINF.	T.	REINF.	T.	REINF.	T.	REINF.	T.	REINF.	T.	REINF.	T.	REINF.	T.	REINF.
1½″ TERRAZZO	4	3	⅜-11	3	⅜-9	3	⅜-10	3	⅜-9	3	⅜-9	3	⅜-8	3	⅜-8	3	⅜-7
	5	3½	8	3½	7	3½	7	3½	6½	3½	6½	3½	6	3½	6	4	6½
	6	4	6	4	6	4	5½	4	5½	4	5½	4	½-9	4	½-9	4½	½-9
	7	4½	½-9	4½	½-9	4½	½-8½	4½	½-8	4½	½-8	5	8	5	8	5	7½
	8	5	8	5	7½	5	7	5	7	5	6½	5½	7	5½	7	5½	6
	9	5½	6½	5½	6½	5½	6	5½	6	5½	5½	6	6	6	6	6	5½
	10	6	6	6	5½	6	5½	6½	5½	6½	⅝-8	6½	⅝-8	6½	⅝-8	6½	⅝-7
	11	6½	⅝-8	6½	⅝-7½	6½	⅝-7½	7	⅝-7½	7	7	7	7	7	7	7½	6½
	12	7	7	7½	7	7½	7	7½	6½	7½	6½	8	6	8	6½	8	6
	13	7½	6	8	6	8	6	8	6	8	6	8½	5½	8½	6	9	5½
	14	8	¾-8	8½	5½	8½	5½	9	5½	9	5½	9	¾-7	9	¾-7½	9½	¾-7
	15	8½	7½	9½	¾-7½	9	¾-7½	9½	¾-7	9½	¾-7	10	6½	9½	6½	10	6½
	16	9½	7	10	6½	9½	6½	10½	6½	10	6½	10½	6	10½	6	11	6
	17	10	6½	10½	6	10½	6	11	6	11	6	11½	⅞-8	11	5½	11½	5½
	18	11	6	11½	5½	11	5½	12	5½	11½	5½	12	7	12	⅞-7½	12½	⅞-7
	19	11½	5½	12	⅞-7½	12	⅞-9	12½	⅞-7	12½	⅞-7½	13	6½	12½	7	13½	6½
	20	12	⅞-7	13	6½	12½	7	13½	6½	13	6½	14	6	13½	6	14½	6
1½″ MARBLE	4	3	⅜-10	3	⅜-9	3	⅜-9	3	⅜-8	3	⅜-8	3	⅜-8	3	⅜-8	3	⅜-7
	5	3½	8	3½	7	3½	7	3½	6	3½	6	3½	5½	3½	5½	4	5½
	6	4	6	4	5½	4	5½	4	½-9	4	½-9	4	½-9	4	½-9	4½	½-9
	7	4½	½-9	4½	½-8	4½	½-8	4½	7	4½	7	5	7	5	7	5	7
	8	5	8	5	7	5	7	5	6½	5	6½	5½	6½	5½	6½	5½	6
	9	5½	7	5½	6	5½	6	5½	5½	5½	5½	6	5½	6	5½	6	5½
	10	6	6	6	5½	6	5½	6½	⅝-8	6½	⅝-8	6½	⅝-8	6½	⅝-8	7	⅝-8
	11	6½	⅝-8	7	⅝-8	6½	⅝-7	7	7	7	7	7½	7	7	7	7½	6½
	12	7	7	7½	6½	7½	6½	7½	6	7½	6	8	6	8	6	8	6
	13	7½	6½	8	6	8	6	8½	5½	8	5½	8½	5½	8½	5½	9	5½
	14	8½	6	8½	5½	8½	5½	9	¾-7½	9	¾-8	9½	¾-7	9	¾-7	9½	¾-7
	15	9	5½	9½	¾-7	9	¾-7	9½	7	9½	7	10	6½	10	6½	10½	6½
	16	9½	¾-7	10	6½	10	6½	10½	6	10½	6½	11	6	10½	6	11	6
	17	10	6½	11	6	10½	6	11	5½	11	6	11½	5½	11½	5½	12	5½
	18	11	6	11½	5½	11	5½	12	⅞-7½	11½	5½	12	⅞-7	12	⅞-7	12½	⅞-7
	19	11½	5½	12½	⅞-7	12	⅞-7½	12½	7	12½	⅞-7	13	6½	12½	6½	13½	6½
	20	12½	⅞-7	13	6	12½	7	13½	6	13	6½	14	6	13½	6	14½	6

CANTILEVER RETAINING WALLS

GENERAL DESIGN

Acknowledgment is made to "Concrete, Plain and Reinforced", for much of the material used herein.

Reinforced concrete retaining walls, whether of tee-shape or ell-shape cantilever, or of counterfort type, are designed for one of three conditions when resisting earth pressures:

1. Level ground. 2. Sloping ground. 3. Surcharged.

With level ground, or with liquids, the pressure is in a horizontal plane; with sloping ground the pressure is in a plane parallel to the degree of slope, angle of which must be known, and when the wall supports a railroad track, building or other structure the line of pressure is horizontal, the surcharge being generally converted into terms of equivalent supported material.

The angle of repose, or angle of internal friction of the material supported must also be considered. Various information necessary in design follows.

ANGLE OF REPOSE

Material	ϕ	cos.
Coal, ballast, etc.	50°	.6428
Earth..........	35°	.8192
Moist sand......	35°	.8192
Clay...........	30°	.8660
Dry sand........	30°	.8660
Wet sand.......	20°	.9397

ANGLE OF SLOPE

Ratio	θ	Sin.	Cos.	Tan.
1 to 1	45°-00′	.7071	.7071	1.0000
1 to 1½	33°-40′	.5544	.8323	.6661
1 to 2	26°-40′	.4488	.8936	.5022
1 to 2½	21°-50′	.3719	.9283	.4006
1 to 3	18°-30′	.3173	.9483	.3346
1 to 4	14°-00′	.2419	.9703	.2493
Level	0°-00′	.0000	1.0000	.0000

CO-EFF. OF FRICTION

Materials	Co-eff.
Masonry on masonry	0.65
Masonry on dry clay	0.50
Masonry on wet clay	0.33
Masonry on sand...	0.40
Masonry on gravel .	0.60

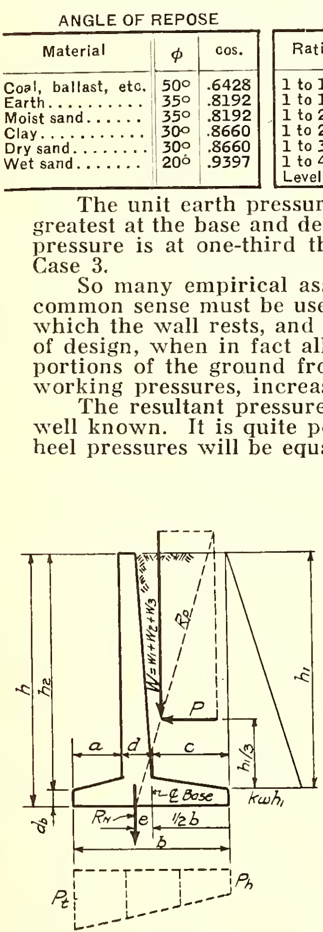
WTS., CU. FT.

Matls.	Wt.
Sand	100
Gravel...	135
Gravel-clay	130
Loam....	90
Hard pan.	130

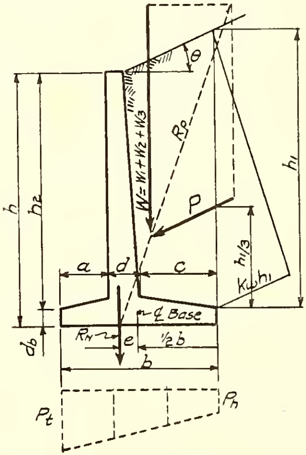
The unit earth pressure against a wall is assumed to be in the form of a triangle, greatest at the base and decreasing to zero at the top. The point of application of the pressure is at one-third the considered height for Case 1 and Case 2, and as noted for Case 3.

So many empirical assumptions enter into the design of retaining walls that much common sense must be used. Particularly is this true with regard to the materials on which the wall rests, and the material it supports. Dry earth may be used as a basis of design, when in fact all the weepholes and drainage tile available would not prevent portions of the ground from becoming saturated. It is therefore advisable to reduce working pressures, increase frictional resistance, etc.

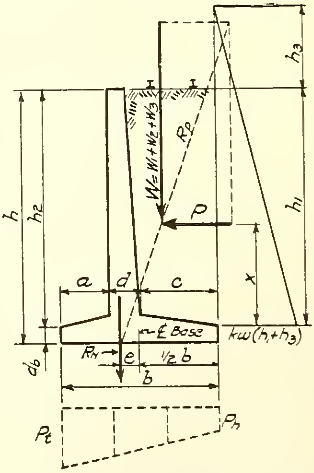
The resultant pressure, R_P, should strike within the middle third of the base, as is well known. It is quite possible to throw the resultant at the center, so that toe and heel pressures will be equal, but it is not economical to do so.



CASE 1



CASE 2



CASE 3

For CASE 3: $h_3 = \text{Load} \div w$. $P = \frac{1}{2}kw(h+2h_3)h$. $x = \frac{h+3h_3}{h+2h_3}\cdot\frac{h}{3}$

NOMENCLATURE:

θ = Angle of slope of ground.
ϕ = Angle of repose of material.
a = Length of toe.
b = Width of base.
c = Length of heel.
d = Effective depth of wall at base.
d_b = Effective depth of base at wall.
e = Eccentricity of R_N from $C.L.$ base.
h = Height of wall, top to bottom of base.
h_1 = Height, top of pressure to top of heel.
h_2 = Height, top of wall to top base.
h_3 = Height, top of pressure to top of wall.

k = Constant =

$$\cos\theta\,\frac{\cos\theta-\sqrt{\cos^2\theta-\cos^2\phi}}{\cos\theta+\sqrt{\cos^2\theta-\cos^2\phi}}$$

m = Ratio length toe to base = $b/_2$ to $b/_3$ in general.
m_1 = Ratio length heel to base.
P = Total pressure acting on wall.
P_t = Toe pressure, max., lbs. sq. ft.
P_h = Heel pressure, max., lbs. sq. ft.
R_P = Resultant pressure.
R_N = Normal or vertical component of R_P.

r = Ratio of design pressure to possible = 1.5 to 2.0.
s = Spacing of counterforts.
w = Weight of earth, lbs. ft3.
W_1 = Weight of Wall Slab.
W_2 = Weight of Base Slab.
W_3 = Weight of Earth.
$W = W_1 + W_2 + W_3$
x = Point of application of P above base, surcharged.

CANTILEVER RETAINING WALLS

DESIGN FORMULAE

The following formulae are to be used in design:

Total Earth Pressure:

$P = \frac{1}{2} kwh_1^2$ applied at $h_1 \div 3$ except for surcharged walls.

$P = \frac{1}{2} kw\,(h + 2h_3)h$, applied at $\dfrac{h + 3h_3}{h + 2h_3}\,\dfrac{h}{3}$, for surcharged walls.

Base Width, resultant in middle third:

$b = 0.94\sqrt{\dfrac{rk}{(1 - m)\,(1 + 3m)}}\,(h)$ for Case 1. $b = 0.94\sqrt{\dfrac{rk \cos \Theta}{(1 - m)\,(1 + 3m)}}\,(h)$ for Case 2.

For resultant at center of footing, giving uniform pressure on base:

$b = 0.55\sqrt{\dfrac{k}{m\,(1 - m)}}\,(h)$ for Case 1. $b = 0.55\sqrt{\dfrac{k \cos \Theta}{m\,(1 - m)}}\,(h)$ for Case 2.

Pressure on Base Slab:

At toe $= P_t = \dfrac{R_N}{b}\left(1 + \dfrac{6e}{b}\right)$ lbs. At heel $= P_h = \dfrac{R_N}{b}\left(1 - \dfrac{6e}{b}\right)$ lbs.

Vertical Wall Slab, maximum Moments:

Case 1. Level ground. $M = \frac{1}{6}kwh_2^3$ ft. lbs. or $2kwh_2^3$ inch lbs.

Case 2. Sloping ground. $M = \frac{1}{6}k \cos \Theta\, wh_2^3$ ft. lbs. or $2k \cos \Theta\, wh_2^3$ inch lbs.

Case 3. Surcharged. $M = \frac{1}{6}kwh_2^2\,(h_2 + 3h_3)$ ft. lbs. or $2kwh_2^2\,(h_2 + 3h_3)$ inch lbs.

Toe Cantilever:

$M = \frac{1}{6}[P_t(3 - m) + m\,P_h]a^2$ ft. lbs. or $2[P_t(3 - m) + mP_h]a^2$ inch lbs; for all cases.

$V = \dfrac{P_t\,(2 - m) + mP_h}{2}\,(a)$ = Maximum shear at edge of wall, all cases.

When pressure at heel (P_h) is zero, omit "mP_h" from above equations.

Heel Cantilever, for case 1, level ground:

$M_1 = 0.55\ whc^2$ ft. lbs. or $6.6\ whc^2$ inch lbs. = Downward moment from weight earth and slab.

$M_2 = \frac{1}{6}\,[P_h\,(3 - m_1) + m_1\,P_t]\,c^2$ ft. lbs or $2\,[P_h\,(3 - m_1) + m_1 P_t]\,c^2$ = inch lbs. = Upward moment from soil pressure.

$M = M_1 - M_2$ = Moment to be used in design.

$V_1 = 1.1\ whc$, lbs. = Downward shear.

$V_2 = \dfrac{P_h\,(2 - m_1) + m_1\,P_t}{2}\,(c)$ lbs. = Upward shear.

$V = V_1 - V_2$ = Resultant shear to be used in design.

Heel Cantilever, for case 2, sloping ground:

$M_1 = \dfrac{1.1}{6}w\,(2h_1 + h + 2)\,c^2$ ft. lbs. or $2.2\,w\,(2h_1 + h + 2)\,c^2$ inch lbs. = Moment due to earth and slab.

$M_2 = \dfrac{1}{6}w\,(2h_1 + h_2)\,K \sin\Theta \tan \Theta\, c^2$ ft lbs. or $2w\,(2h_1 + h_2)\,K \sin \Theta \tan \Theta\, c^2$ inch lbs. = Mom. due to Vert. Comp.

$M_3 = \dfrac{c^2}{6}\,[P_h(3 - m_1) + m_1 P_t]$ ft. lbs. or $2\,[P_h\,(3 - m_1) + m_1\,P_t]\,c^2$ inch lbs. = Mom. for upward pressure.

$M = M_1 + M_2 - M_3$ = Moment to be used in design.

$V_1 = 0.55\ (h + h_1 + 1)\ wc$ lbs. = Downward shear, weight of earth and slab.

$V_2 = \frac{h_1 + h_2}{2} K \sin \theta \tan \theta\ wc$ lbs. = Downward shear, vertical component.

$V_3 = \frac{1}{2}\ [P_h\ (2 - m_1) + m_1 P_t] c$ lbs. = Upward pressure.

$V = V_1 + V_2 - V_3$ = Resultant shear to be used in design.

General Note:

Formulae for A_s, d, v and u are standard.

Temperature Reinforcing:

At least 0.2% of the volume of concrete should be used for temperature bars, about ⅔ being placed horizontally in the outer face of cantilever walls. For watertight walls the percentage should be increased to 0.4 or 0.5 per cent.

GRAVITY WALLS.

Retaining walls of gravity type are generally more expensive than reinforced cantilever walls to meet the same conditions, and for this reason are seldom used.

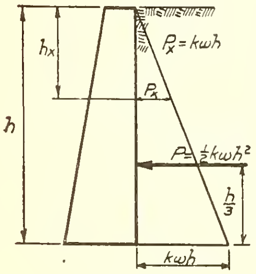
The methods to be employed in computing pressures on foundation and line of pressure on wall are similar to those used in the design of reinforced walls.

Many tables have been prepared, giving required width of base for given ratios of height, etc., but these are not wholly satisfactory. On walls of any importance detailed designs should be made. On unimportant work it is usually sufficiently safe to make the base width ⅜ to ½ of the height, for walls without surcharge.

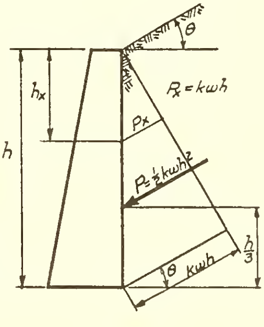
It is customary to batter the face of gravity walls, 1½ to 12, with the rear side vertical. This fixes the top width.

Gravity type walls are especially susceptible to uneven settlement, caused by poor drainage, and to tipping and cracking under uneven loading.

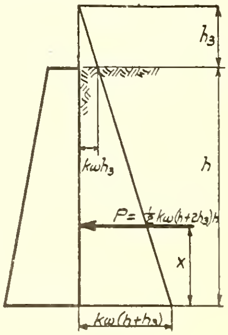
The distribution of earth pressure on gravity walls is as shown:



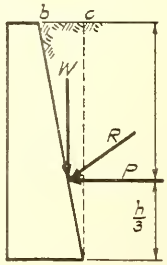
Case 1



Case 2



Case 3



Inclined Back

On gravity walls with inclined backs, the earth pressure R is the resultant of the horizontal pressure, P, on the vertical plane "*ac*", and W, the weight of earth, "*abc*".

RESISTANCE TO SLIDING.

On any wall, gravity or reinforced cantilever, the tendency to slide is resisted by the friction between base and earth; the earth in front of wall cannot be relied upon. The friction is equal to the vertical pressure multiplied by the tangent of the angle of friction between concrete and earth, or $F = (W_1 + W_2 + R_n) \tan \triangle$, where F = friction, and $\triangle$ = angle of friction as noted.

RETAINING WALLS

COUNTERFORTED AND OTHER TYPES

Counterforted walls are seldom economical for heights less than 18'-0" to 20'-0".

The design is similar to that of cantilever walls, save for a few exceptions. The vertical wall slab is figured for continuity as a beam, loaded by the earth pressure and supported by the counterforts. The principal, or moment, steel is horizontal instead of vertical. The wall should be divided into one foot horizontal strips for design purposes, the loading on each strip varying from a maximum at the bottom to a minimum at the top, in accordance with variation of earth pressure on the wall.

Bending moments for wall designs are $M = wl^2 \div 12$ for interior panels, and $M = wl^2 \div 10$ for end.

The slab thickness is computed for maximum pressure at base and may be sloped to top.

The simplest way to ascertain the varying moment in each strip is to plot the height of wall graphically in a vertical plane to scale and the maximum bottom strip moment horizontally. The enclosed triangle will give moments at any point.

The reinforcement at center of span between counterforts should be at the outer face of wall. Steel for negative moment over the counterfort should be used at the inner face of wall.

The counterforts may be designed as Tee-beams, utilizing the wall slab as Tee. The thickness of the counterfort should preferably be about $\frac{1}{20}$ the wall height, but must at all events be sufficient for diagonal tension. A minimum thickness of 12" is desirable.

Spacing of counterforts should be not less than 6'-6" or 7'-0" for low walls, while for higher walls it should be $s = 2.46 + 0.216h$.

The toe cantilever is designed as for cantilever walls.

The heel cantilever or horizontal base slab should be considered as divided into one foot strips, parallel to the wall. The greatest load will be carried by strip at rear edge, varying to minimum at wall.

For level ground the strip loading consists of the strip weight and of the earth above it, less the upward foundation pressure.

For inclined ground the load consists of the weight of slab and earth, plus the vertical component of the earth pressure. This component is

At edge of base $= Kwh_1 \sin\theta \tan\theta$ lbs. sq. ft.
At wall $= Kwh_2 \sin\theta \tan\theta$ lbs. sq. ft.

The loading for any intermediate strip may be scaled from plotting of the above.

In designing the counterforts themselves:

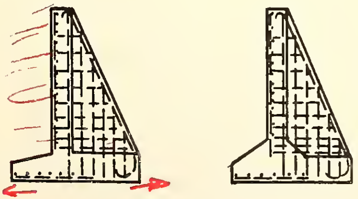
$P = \frac{1}{2}K \cos\theta\, wh_2^2 s$ lbs.
$M = 2K \cos\theta\, wh_2^3 s$ inch lbs.

The total pressure and the maximum moment act at the juncture of base and counterfort. They may be found at any other point by substituting for h_2.

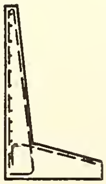
Area of steel for moment in counterfort is found as for any other Tee-beam. The moment decreases rapidly from base upward, as does the effective depth. The amount of reinforcement may be reduced by making some of the bars shorter as the required A_s decreases upward. All main bars must be securely anchored at the bottom by bending them back into the base slab, and they should also be hooked at each end.

Horizontal stirrups should be used to tie the wall to the counterfort, whether or not they are needed for diagonal tension. Vertical stirrups should also be used to tie the counterfort to the base, of area sufficient to transfer by tension in the steel all the downward load from base to counterfort.

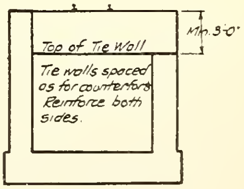
When retaining walls are not allowed to project on adjoining property they are often made L-shaped, with the toe cantilever omitted. The design offers no particular difficulties, but this type of wall is not economical. Cellular walls may also be used, and are particularly advantageous where heavy surcharges are encountered or where toe pressures are excessive for L-shaped walls. Consult some recognized textbook for design of cellular walls.



COUNTERFORTED WALLS



L-WALL



CELLULAR WALL

CANTILEVER RETAINING WALL

TYPICAL EXAMPLE

Height (h) = 18′-0″. Supporting earth, slope 1 to 2½. Resistance to sliding 0.40.
Unit stresses: $f_c = 700$; $f_s = 18{,}000$; $n = 15$; $v = 40$; $u = 100$; $R = 113.1$. Ratio "m" = 0.30.
Angle of slope, 1 to 2½ = θ = 21°50′; *cos* = .9283. Angle of repose = φ = 35°; *cos.* .8192.

$$K = \cos\theta\,\frac{\cos\theta - \sqrt{\cos^2\theta - \cos^2\phi}}{\cos\theta + \sqrt{\cos^2\theta - \cos^2\phi}} = .9283\,\frac{.9283 - \sqrt{.8617 - .6711}}{.9283 + \sqrt{.8617 - .6711}} = 0.33.$$

$$b = 0.94\sqrt{\frac{1.5 \times 0.33 \times .9283}{(1 - 0.30)\ (1 + 0.90)}}\ (18) = 9.93'$$, say 10′-0″. Length toe = 0.30 × 10.0 = 3.0′. Lay out to scale.

$P = \frac{1}{2} \times .33 \times 100 \times 19.5^2 = 6{,}300\#$ at point $\frac{19.5}{3} = 6.5'$ above base.

To find center of gravity of all loads: Assume 12″ depth of base and wall.

	Loads	Dist. to C.G.	Moments
Slab $= W_1 = 17 \times 1.00 \times 150$	= 2,550	$6.0 + 0.5 = 6.50$	16,600
Base $= W_2 = 10 \times 1.00 \times 150$	= 1,500	$10 \div 2 = 5.00$	7,500
Earth $= W_3 = 6 \times \frac{17 + 19.5}{2} \times 100$	= 10,950	$\frac{6}{3}\ \frac{19.5 + (2 \times 17)}{19.5 + 17} = 2.93$	32,200
	$W = 15{,}000$		$M = 56{,}300$

Distance from heel to center gravity $= \frac{M}{W} = \frac{56{,}300}{15{,}000} = 3.75'$.

Laying out $W = 15{,}000$ and $P = 6{,}300$, to scale, the resultant falls within the middle third.
The components of the earth pressure are: $H = P\cos\theta = 6{,}300 \times .9283 = 5{,}850$.
$V = P\sin\theta = 6{,}300 \times .3719 = 2{,}340$.
The vertical or normal component of the resultant $= R_N = W + V = 15{,}000 + 2{,}340 = 17{,}340$.

Eccentricity, or "e" $= \frac{10}{2} - 4 = 1.0'$.

P_t = Toe pressure $= \frac{17{,}340}{10}(1 + 0.6) = 2{,}780\#/\square'$. P_h = Heel pressure $= \frac{17{,}340}{10}(1 - 0.6) = 695\#/\square'$.

Toe Cantilever:

$M = 2\,[2{,}780\,(3.0 - 0.3) + 0.3 \times 695]\,3^2 = 138{,}500$ in. lbs.

$d_b = \sqrt{\frac{138{,}500}{113.1 \times 12}} = 10.20''$ (Depth for moment).

$A_s = \frac{138{,}500}{.875 \times 10.2 \times 18{,}000} = 0.86\square''$ ¾φ @ 6″ cts; $\Sigma_0 = 4.72\square''$ per ft.; extend 40 dia. or 2′-6″ past edge of wall.

$V = \frac{(2{,}780 \times 1.70) + 0.30 \times 695}{2}\ (3) = 7{,}400$. $u = \frac{7{,}400}{4.72 \times .875 \times 10.2} = 175\#/\square''$. Excessive for straight bars.

Required depth for bond $= 10.2 \times \frac{175}{100} = 17.9''$. Req'd depth for 40# shear $= \frac{7{,}400}{.875 \times 12 \times 40} = 17.7''$. Use $d_b = 18''$, plus $3'' = 21''$.

Heel Cantilever:

$M_1 = 2.2 \times 100\,(2 \times 19.5 + 18 + 2)\,(6)^2 = 467{,}000$ in. lbs.
$M_2 = 2 \times 100\,(2 \times 19.5 + 17) \times 0.33 \times .3719 \times .4006 \times 6^2 = 19{,}850$ in. lbs.
$M_3 = 2\,[695\,(3.0 - 0.6) + 0.6 \times 2{,}780]\,6^2 = 240{,}000$ in. lbs.
$M = 467{,}000 + 19{,}850 - 240{,}000 = 246{,}850$ in. lbs.

$d_b = \sqrt{\frac{246{,}850}{113.1 \times 12}} = 13.5''$; Req'd. depth for toe was 18″, which will be used.

$A_s = \frac{246{,}850}{.875 \times 18 \times 18{,}000} = .87\square''$ ¾φ @ 6″ cts; $\Sigma_0 = 4.72\square''$ per ft.; extend 40 dia. or 2′-6″ past edge of wall.

$V_1 = 0.55\,(18 + 19.5 + 1)\,100 \times 6 = 12{,}350$.

$V_2 = \frac{19.5 + 17}{2} \times 0.33 \times .3719 \times .4006 \times 100 \times 6 = 540$.

$V_3 = \frac{1}{2}\,[695\,(2.0 - 0.6) + (0.6 \times 2{,}780)]\,6 = 7{,}940$. $V = 12{,}350 + 540 - 7{,}940 = 4{,}950\#$.

$u = \frac{4{,}950}{4.72 \times .875 \times 18} = 67\,\#\square''$ OK. Depth req'd. for shear $= \frac{4{,}950}{12 \times .875 \times 40} = 11.8''$ (18″ is used).

Vertical Wall:

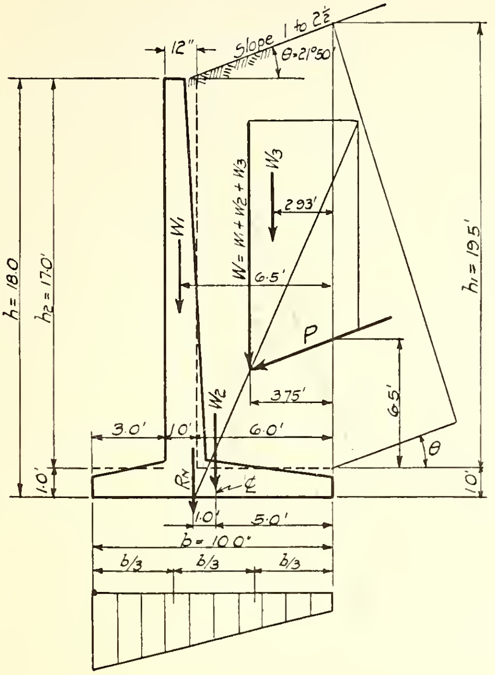
$M = 2 \times 0.33 \times .9283 \times 100 \times 16.25^3 = 263{,}000$ in. lbs.

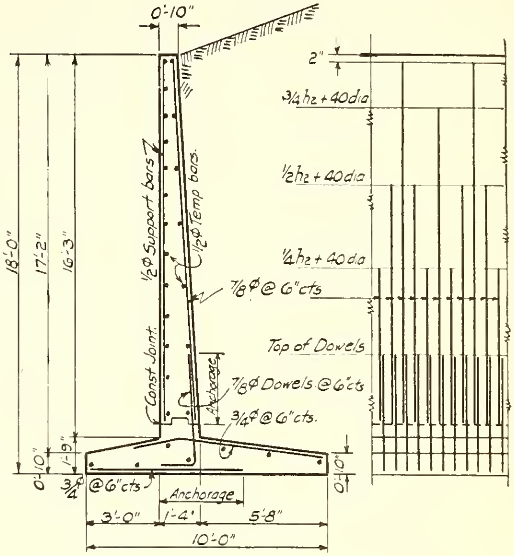
$d = \sqrt{\frac{263{,}000}{113.1 \times 12}} = 13.9''$; $A_s = \frac{263{,}000}{.875 \times 13.9 \times 18{,}000} = 1.2\square''$ ⅞φ @ 6″ cts.

Use 1.5″ protection over bars: $1.5 + \frac{.875}{2} = 1.94''$. Say 2″ from center of steel, making total thickness at bottom $13.9 + 2.0 = 16''$.

CANTILEVER RETAINING WALLS

TYPICAL EXAMPLE


12"
Slope 1 to 2½
θ=21°50'
W=W1+W2+W3
W3
2.93'
W1
6.5'
P
h=18.0
h2=17.0'
h1=19.5'
W2
3.75'
6.5'
θ
3.0'
1.0'
6.0'
1.0'
Rv
℄
1.0'
5.0'
1.0'
b=10.0'
b/3
b/3
b/3


0'-10"
2"
¾h2+40dia
½h2+40dia
¼h2+40dia
7/8φ@6"cts
Top of Dowels
7/8φ Dowels @6"cts
¾φ@6"cts.
Anchorage
½φ Support bars
½φ Temp bars
Const. Joint
18'-0"
17'-2"
16'-3"
1'-9"
0'-10"
¾φ @6"cts
Anchorage
3'-0"
1'-4"
5'-8"
10'-0"
0'-10"

It is not necessary to extend all the main vertical bars the full height of wall, since there is no moment at the top, and at intermediate points it varies as the third power of the height. For ordinary walls it is sufficient to compute the moment at quarter points of the height, and extend enough bars to satisfy this requirement. The moment will be as mentioned for ratios of $h_x \div h$; the wall should be a minimum of 10" thick at top, sloping uniformly to 16" at bottom. The "*d*" of wall, at quarter points, varies.

Height h_x	Ratio $\frac{h_x}{h}$	$\frac{h_x^3}{h}$	*d*	*M*" /#s	A_s
¼*h* = 4.06'	.25	.0156	9.475	4,100	.03
½*h* = 8.13'	.50	.125	10.95	32,900	.19
¾*h* = 12.20'	.75	.422	12.425	111,000	.57
h = 16.25'	1.00	1.000	13.9	263,000	1.20

Bars should extend 40 diameters past the point where theoretically needed or 3'-0" for ⅞φ bars.
For 1st strip, length = 4.08+3.0= 7'-1". A_s=1.20
For 2nd " " = 8.13+3.0=11'-2". A_s=0.57
For 3rd " " = 12.2 +3.0=15'-3". A_s=0.19

Specifications ordinarily limit the spacing of bars to a maximum of 3 times the slab thickness. In this case, maximum spacing would be 3×10 = 30", but it is not always necessary to hold strictly to this requirement. The arrangement shown above will suffice.

Temperature and shrinkage bars equal to 0.2% of the gross wall area would be (10+16)÷2×16.25×12×.002 = 5.08□". Two thirds, or about 3.4□", should be placed in the outer face, with the remainder 1.68□", in the inner face. If ½φ bars are used, with area of .196 each, 17 will be used in face and 8 in rear. Both sets will be placed horizontally, those in face being tied to ½φ vertical bars spaced say 24" cts., while those in back may be fastened directly to vertical moment bars.

Horizontal temperature bars should lap 40 diameters; they may be equally spaced in vertical height of wall if the wall has comparatively little taper, or spacing may be varied in tapered walls to suit change in cross-section, being closely spaced near bottom and increasing the spacing toward top.

Dowels, of same size and at same spacing as main vertical steel should be placed when base is poured to facilitate construction. They should extend 40 diameters into the base, bent as shown, and project 40 diameters above it.

Longitudinal bars, say ½φ @ 24" centers, should be placed in the base as shown.

BASEMENT WALLS

GENERAL:

Reinforced concrete basement walls, designed as beams loaded by earth pressure are of two types: Case 1. Supported at top and bottom, reinforced vertically.
Case 2. Supported by columns, reinforced horizontally.

If conditions are unusual the earth pressure should be found as for retaining walls. Ordinarily, however, a pressure equivalent to 30 lbs. fluid pressure per cu. ft. is amply safe. When walls are parallel and adjacent to a street, alley or railroad, there will be an additional surcharge. The amount of surcharge, in terms of additional height, should be as follows: For alleys or streets, 3 ft. For railroads, 6 to 10 ft., depending on distance to track.

Without surcharge the earth pressure is zero at ground level and a maximum of "wh" at basement floor level. With surcharge the pressure at ground level is $w_1 = wh_x$, and at basement level, $w_2 = w\,(h + h_x)$. Basement walls should be a minimum of 8″ in thickness to prevent ground water leakage.

Nomenclature.

w = Max. unit earth pressure, lbs. ft².
w_1 = Unit earth pressure, top surcharged walls.
w_2 = Unit earth pressure, bottom surchargeed walls.
h = Height of wall in feet.
h_x = Height of surcharge, in feet.
R_1 = Reaction at top.
R_2 = Reaction at bottom.
M = Maximum bending moment.
x_1 = Distance from top to point of max. moment.

Formulae:

No surcharge: $R_1 = \frac{1}{3}\,\frac{wh}{2}$ $\qquad M = 0.064\,wh^2$ ft. lbs. $\qquad x_1 = \frac{1}{\sqrt{3}}\,(h) = 0.58h.$

$R_2 = \frac{2}{3}\,\frac{wh}{2}$ $\qquad = 0.77\,wh^2$ inch lbs.

With surcharge: $R_1 = \frac{2w_1 + w_2}{6}\,(h)$ $\qquad M = \frac{1}{8}\,\frac{w_1 + w_2}{2}\,(h)^2$ ft. lbs. (approx.)

$R_2 = \frac{w_1 + 2w_2}{6}\,(h)$ $\qquad = 0.75\,(w_1 + w_2)\,h^2$ inch lbs. (approx.)

$$x_1 = \frac{1}{2\,(c-1)}\left[-1 \mp \sqrt{\frac{2}{3}\,(2+c)\,(c-1) + 1}\,\right] h \qquad \text{where } c = \frac{w_2}{w_1}$$

EXAMPLES: Case 1. Supported Top and Bottom:

Distance fin. floor to floor 12′-0″. Ground level with 1st floor. Cols. 30″ square, spaced 18′-0″ cts. One wall no surcharge; other adjacent to alley. Height of wall from center of 4″ first floor slab to point 6″ below basement floor level (allows 12″ embedment) = (12′-0″ — 0′-2″) + 0′-6″ = 12′-4″.

(*a*) No surcharge:

$w = 12.33 \times 30 = 370$#. M $= 0.77 \times 370 \times 12.33^2 = 43{,}300$″/#s per ft. wall.

Assume 12″ wall, $d = 10.5$.

$A_s = \frac{M}{jdf_s} = \frac{43{,}300}{.875 \times 10.5 \times 18{,}000} = 0.27$□″ or ½φ @ 9″ cts.

Ratio of steel to concrete $= p = \frac{.27}{12 \times 10.5} = .00214$

Allowable p = .00716 for $f_c = 700$#. Compression OK.

(*b*) With surcharge:

$w_1 = 3 \times 30 = 90.$ $\quad w_2 = (3 + 12.33)\,30 = 460.$ $\quad M = 0.75 \times (90 + 460)\,12.33^2 = 62{,}700$″/#s.

$A_s = \frac{62{,}700}{.875 \times 10.5 \times 18{,}000} = 0.38$□″ or ⅝φ @ 9″ cts. $\quad p = \frac{.38}{12 \times 10.5} = .00301.$ Comp. OK.

Case 2. Supported at Columns:

Net span 18-0 — 2-6 = 15-6. Height of wall, 1st Fl. to bottom basement slab = 12-0 + 0-4 = 12′-4″.

(*c*) No surcharge:

$w = 12.33 \times 30 = 370.$ $\quad M = wl^2 = 370 \times 15.5^2 = 89{,}000$″/#s at bottom strip 1′-0″ wide.

For 12″ wall, $d = 10.5$. $\quad A_s = \frac{89{,}000}{.875 \times 10.5 \times 18{,}000} = 0.54$□″ or ⅝φ @ 7″.

Moments reduce to zero at top; plot for determination at intermediate points of triangle. $\quad p = \frac{54}{12 \times 10.5} = .0043.$ Comp. OK.

(*d*) With surcharge:

$w_1 = 3 \times 30 = 90.$ $\quad w_2 = (3 + 12.33)\,30 = 460.$

At top: $M = 90 \times 15.5^2 = 21{,}600$″/#s. $\quad A_s = \frac{21{,}600}{.875 \times 10.5 \times 18{,}000} = 0.13$□″ — ⅝φ @ 24″.

At bottom: $M = 460 \times 15.5^2 = 110{,}600$″/#s. $\quad A_s = \frac{110{,}600}{.875 \times 10.5 \times 18{,}000} = 0.67$□″ — ⅝φ @ 5½″.

Plot trapezoid for moments at intermediate points. $\quad p = \frac{.67}{12 \times 10.5} = .0053.$

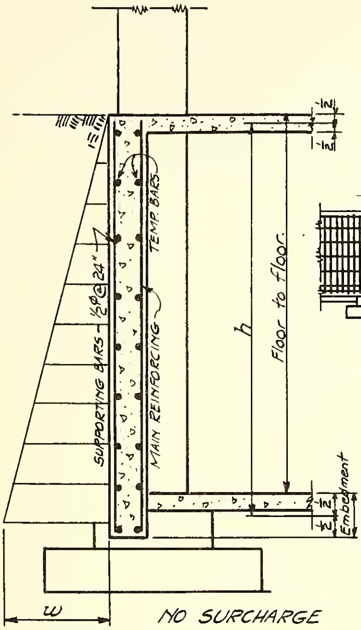
TEMPERATURE BARS: Provide temperature bars for all above examples as for retaining walls.

GENERAL NOTE: In end spans, Case 2, the area of steel should be increased 20%. Negative moment at columns, Case 2, may be provided for by bending half the bars into outer face of slab and extending to ¼ point of adjacent span, or by running bars straight in inner face continuous for positive moment and adding short straight bars over columns in outer face for negative *M*. In Case 2, earth pressure from slab produces bending in column, equal to pressure per foot of wall times span. This should be investigated, especially if columns are small, with light loads.

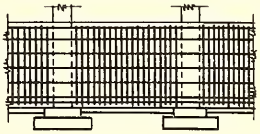
BASEMENT WALLS

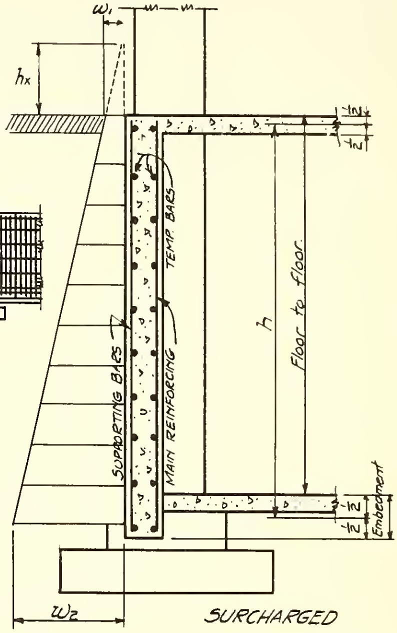
TYPICAL DESIGNS

SUPPORTED TOP AND BOTTOM
REINFORCED VERTICALLY


TEMP. BARS
SUPPORTING BARS ½"φ@24"
MAIN REINFORCING
h
Floor to floor
t/2
Embedment
w

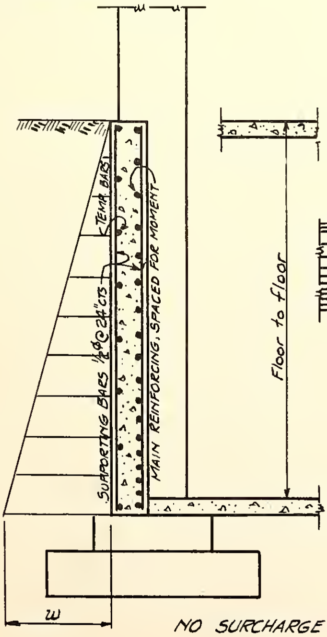
NO SURCHARGE



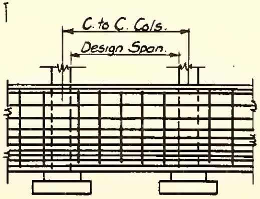

w₁
hₓ
TEMP. BARS
SUPPORTING BARS
MAIN REINFORCING
h
Floor to floor
t/2
Embedment
w₂

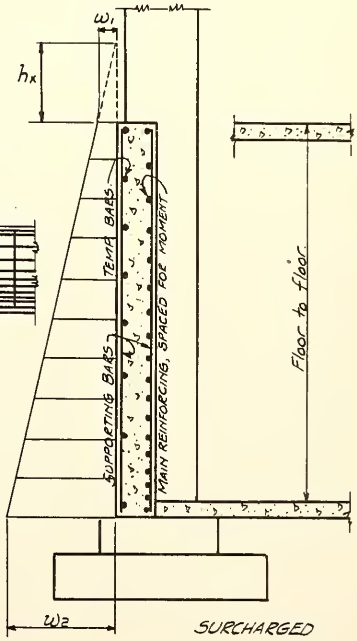
SURCHARGED

SUPPORTED AT COLUMNS
REINFORCED HORIZONTALLY


TEMP. BARS
SUPPORTING BARS ½"φ@24"CTS.
MAIN REINFORCING, SPACED FOR MOMENT
Floor to floor
w

NO SURCHARGE


C. to C. Cols.
Design Span

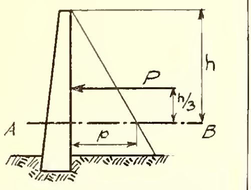

w₁
hₓ
TEMP. BARS
SUPPORTING BARS
MAIN REINFORCING, SPACED FOR MOMENT
Floor to floor
w₂

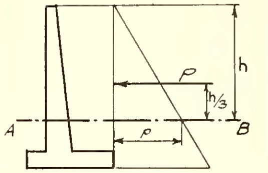
SURCHARGED

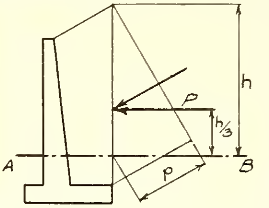
RETAINING WALLS

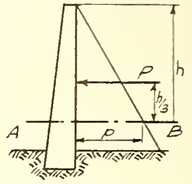
EARTH AND WATER PRESSURES

p = Intensity of pressure, any depth "h"
P = Total horizontal pressure above A-B
M = Moment, at Section A-B









h	SATURATED EARTH —HORIZONTAL W = 75 lb.			DRY EARTH —HORIZONTAL W = 100 lb.			EARTH—SURCHARGED W = 100 lb.			WATER W = 62.5 lb.		
In Feet	p = wh	P = 0.5 ph	M = 4 Ph	p = 0.2984 wh	P = $0.1474 wh^2$	M = $0.5896 wh^3$	p = 0.7034 wh	P = $0.3517 wh^2$	M = $1.4068 wh^3$	p = wh	P = 0.5 ph	M = 4 Ph
	lb.	lb.	in. lb.	lb.	lb.	in. lb.	lb.	lb.	in. lb.	lb.	lb.	in. lb.
1	75	38	150	30	15	59	70	35	140	63	31	125
2	150	150	1,200	60	60	472	140	140	1,125	125	125	1,000
3	225	338	4,050	88	132	1,592	210	317	3,800	188	280	3.375
4	300	600	9,600	118	236	3,773	280	563	9,000	250	500	8,000
5	375	940	18,750	147	368	7,370	352	879	17,580	313	780	15,625
6	450	1,350	32,400	177	530	12,735	422	1,265	30,385	375	1.125	27,000
7	525	1,840	51,450	205	720	20,225	492	1,725	48,250	438	1,531	42,875
8	600	2,400	76,800	235	945	30,190	563	2,250	72,020	500	2,000	64,000
9	675	3,040	109,350	265	1,193	42,980	633	2,850	102,550	563	2,531	91,125
10	750	3,750	150,000	295	1,475	58,960	703	3,517	140,670	625	3,125	125,000
11	825	4,540	199,650	325	1,782	78,475	775	4,255	187,235	688	3,781	166,375
12	900	5,400	259,200	355	2,125	101,880	845	5,065	243,080	750	4,500	216,000
13	975	6,340	329,550	383	2,490	129,535	915	5,945	309,000	813	5,281	274,600
14	1,050	7,350	411,600	413	2,890	161,785	985	6,895	386,000	875	6,125	343,000
15	1,125	8,440	506,250	442	3,315	198,990	1,055	7,915	374,800	938	7,031	421,900
16	1,200	9,600	614,400	472	3,775	241,500	1,125	9,000	576,200	1,000	8,000	512,000
17	1,275	10,840	736,950	500	4,260	289,700	1,195	10,165	691,100	1,063	9,031	614,125
18	1,350	12,150	874,800	530	4,780	343,900	1,266	11,395	820,400	1,125	10.125	729,000
19	1,425	13,540	1,028,850	560	5,320	404,400	1,336	12,695	964,900	1,188	11,281	857,400
20	1,500	15,000	1,200,000	590	5,900	471,700	1,407	14,067	1,125,400	1,250	12,500	1,000,000
21	1,575	16,540	1,389,150	620	6,500	546,000	1,477	15,500	1,302,800	1,313	13,781	1,157,600
22	1,650	18,150	1,597,200	650	7,140	627,800	1,547	17,020	1,497,900	1,375	15,125	1,331,000
23	1,725	19,840	1,825,050	678	7,795	717,370	1,618	18,600	1,711,575	1,438	16,530	1,520,900
24	1,800	21,600	2,073,600	708	8,500	815,000	1,688	20,255	1,944,700	1,500	18,000	1,728,000
25	1,875	23,440	2,343,750	737	9,215	921,250	1,758	21,980	2,198,000	1,563	19,531	1,953,100
26	1,950	25,350	2,636,400	766	9,960	1.036,300	1,829	23,775	2,472,500	1.625	21.125	2,197,000
27	2,025	27,340	2,952,450	796	10,745	1,160,500	1,900	25,640	2,768,900	1,688	22,780	2,460,400
28	2,100	29,400	3,292,800	825	11,550	1,294,300	1,970	27,570	3,088,000	1,750	24,500	2,744,000
29	2,175	31,540	3,658,350	855	12,400	1,438,000	2,040	29,580	3,430,900	1,813	26,280	3,048,600
30	2,250	33,750	4,050,000	885	13,260	1,592,000	2,110	31,650	3,798,200	1.875	28,125	3,375,000
31	2,325	36,040	4,468,650	915	14,167	1,756,500	2,180	33,800	4,190,800	1,938	30,030	3,723,900
32	2,400	38,400	4,915,200	943	15,090	1,932,000	2,250	36,000	4,609,600	2,000	32,000	4,096,000
33	2,475	40,840	5,390,550	973	16,045	2,118,850	2,320	38,300	5,055,380	2,063	34,030	4,492,100
34	2,550	43,350	5,895,600	1,000	17,035	2,317,350	2,390	40,650	5,529,000	2,125	36,125	4,913,000
35	2,625	45,940	6,431,250	1,030	18,060	2,528,000	2,462	43,080	6,031,400	2,188	38,280	5,359,400

PART II

STRUCTURAL STEEL DESIGN

TABLE OF SECTION MODULII

FOR VARIOUS STRUCTURAL STEEL BEAMS

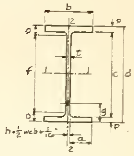
S = SECTION MODULUS	DEPTH OF SECTION	WEIGHT PER FOOT	TYPE	S = SECTION MODULUS	DEPTH OF SECTION	WEIGHT PER FOOT	TYPE	S = SECTION MODULUS	DEPTH OF SECTION	WEIGHT PER FOOT	TYPE
1105.1	36	300	WF	139.9	21	68	WF	37.8	12	35	I
1031.2	36	280	WF	138.1	14	87	WF	36.0	12	31.8	I
951.1	36	260	WF	134.7	12	99	WF	35.5	8	40	WF
892.5	36	245	WF	130.9	14	84	WF	35.0	10	33	WF
835.5	36	230	WF	128.2	18	70	WF	34.1	12	27	WF
811.1	33	240	WF	127.8	16	78	WF	31.1	8	35	WF
740.6	33	220	WF	126.4	21	62	WF	30.8	10	29	WF
669.6	33	200	WF	126.3	20	75	I	29.2	10	35	I
663.6	36	194	WF	126.3	10	112	WF	28.9	8	34.3	H
649.9	30	210	WF	125.0	12	92	WF	27.4	8	31	WF
621.2	36	182	WF	121.1	14	78	WF	26.9	12	30	[
586.1	30	190	WF	117.0	18	64	WF	26.4	10	25	WF
579.1	36	170	WF	116.9	20	65.4	I	25.3	12	22	LB
541.0	36	160	WF	115.9	16	71	WF	24.4	10	25.4	I
528.2	30	172	WF	115.7	12	85	WF	24.3	8	28	WF
502.9	36	150	WF	112.4	10	100	WF	23.9	12	25	[
492.8	27	177	WF	112.3	14	74	WF	21.5	10	21	WF
486.4	33	152	WF	107.8	18	60	WF	21.4	12	19	LB
446.8	33	141	WF	107.1	12	79	WF	21.4	12	20.7	[
444.5	27	160	WF	104.2	16	64	WF	20.8	8	24	WF
413.5	33	130	WF	103.0	14	68	WF	20.6	10	30	[
404.8	24	160	WF	101.9	18	70	I	18.8	10	19	LB
402.9	27	145	WF	99.7	10	89	WF	18.1	10	25	[
379.7	30	132	WF	98.2	18	55	WF	17.5	12	16.5	LB
372.5	24	145	WF	97.5	12	72	WF	17.0	8	20	WF
354.6	30	124	WF	94.1	16	58	WF	16.8	6	25	WF
330.7	24	130	WF	92.2	14	61	WF	16.2	10	17	LB
327.9	30	116	WF	89.0	18	50	WF	16.0	8	23	I
317.2	21	142	WF	88.4	18	54.7	I	15.7	10	20	[
299.2	30	108	WF	88.0	12	65	WF	15.7	6	25	M
299.2	27	114	WF	86.1	10	77	WF	14.8	12	14	LB
299.1	24	120	WF	80.7	16	50	WF	14.2	8	18.4	I
284.1	21	127	WF	80.1	10	72	WF	14.1	8	17	WF
274.4	24	110	WF	78.1	12	58	WF	13.8	10	15	LB
266.3	27	102	WF	77.8	14	53	WF	13.5	9	20	[
263.2	12	190	WF	74.5	18	58	[	13.4	10	15.3	[
250.9	24	120	I	73.7	10	66	WF	13.4	6	20	WF
249.6	21	112	WF	72.4	16	45	WF	12.0	12	11.8	JB
248.9	24	100	WF	70.7	12	53	WF	12.0	7	20	I
242.8	27	94	WF	70.2	14	48	WF	11.8	8	15	LB
234.3	24	105.9	I	69.1	18	51.9	[	11.3	9	15	[
222.2	12	161	WF	67.1	10	60	WF	10.9	8	18.75	[
220.9	24	94	WF	64.7	12	50	WF	10.5	10	11.5	LB
220.1	18	114	WF	64.4	16	40	WF	10.5	9	13.4	[
216.0	14	136	WF	64.2	15	50	I	10.4	7	15.3	I
202.2	18	105	WF	63.7	18	45.8	[	10.1	6	15.5	WF
202.0	14	127	WF	62.7	14	43	WF	10.1	6	16	LB
197.6	21	96	WF	61.0	18	42.7	[	9.9	8	13	LB
197.6	24	100	I	60.4	10	54	WF	9.9	5	18.5	WF
196.3	24	84	WF	60.4	8	67	WF	9.6	11	10.3	JB
189.4	14	119	WF	58.9	15	42.9	I	9.3	12	10.6	J[
185.8	24	90	I	58.2	12	45	WF	9.0	8	13.75	[
184.4	18	96	WF	56.3	16	36	WF	8.7	6	17.25	I
182.5	12	133	WF	54.6	14	38	WF	8.5	5	16	WF
176.3	14	111	WF	54.6	10	49	WF	8.1	8	11.5	[
175.4	24	76	WF	53.6	15	50	[	7.8	10	9	JB
173.9	24	79.9	I	52.0	8	58	WF	7.8	8	10	LB
168.0	21	82	WF	51.9	12	40	WF	7.7	7	14.75	[
166.1	16	96	WF	50.3	12	50	I	7.3	6	12.5	I
163.6	14	103	WF	49.1	10	45	WF	7.2	6	12	Lb
163.4	12	120	WF	48.5	14	34	WF	6.9	7	12.25	[
160.0	20	95	I	46.2	15	40	[	6.5	10	8.4	JB
156.1	18	85	WF	45.9	12	36	WF	6.0	7	9.8	[
151.3	16	88	WF	44.8	12	40.8	I	6.0	5	14.75	I
150.7	21	73	WF	43.2	8	48	WF	5.8	9	7.5	JB
150.6	14	95	WF	42.2	10	39	WF	5.8	6	13	[
150.2	20	85	I	41.8	14	30	WF	5.4	4	13	WF
144.5	12	106	WF	41.7	15	33.9	[	5.1	6	8.5	LB
141.7	18	77	WF	39.4	12	31	WF	5.0	6	10.5	[

I = Moment of Inertia, in.^{4}
S = Section Modulus, in.^{3}
r = Radius of Gyration, in.
M = Bending Moment, kip ft.
V = Max. Web Shear, kips
R = Max. Reaction, 3½" bearing, kips
M is given for 18000 and 20000 fiber stress; V for unit shear = 13000

WIDE FLANGE SHAPES

1946 SIMPLIFIED LIST

PARALLEL FLANGE



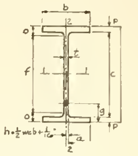
NOM. DEPTH	NOM. WIDTH	WT. PER FOOT	AREA SQ. IN.	Dimensions									Axis 1-1			Axis 2-2			M		V	R
				d	b	p	t	f	o	h	a	g	I	S	r	I	S	r	18000	20000		
5"	5	16	4.70	5	5	3/8	1/4	3 11/16	5/8	3/16	2 3/8	2	21.3	8.5	2.13	7.5	3.0	1.26	13	14	16	24
		18.5	5.45	5 1/8	5	7/16	1/4	3 11/16	3/4	3/16	2 3/8	2	25.4	9.9	2.16	8.9	3.5	1.28	15	16	18	27
6"	6	15.5	4.62	6	6	1/4	1/4	4 7/8	9/16	3/16	2 7/8	2	30.3	10.1	2.56	9.7	3.2	1.45	15	17	19	23
		20	5.90	6 1/4	6	3/8	1/4	4 7/8	11/16	3/16	2 7/8	2	41.7	13.4	2.66	13.3	4.4	1.50	20	22	21	26
		25	7.37	6 3/8	6	1/2	5/16	4 7/8	3/4	1/4	2 7/8	2 1/4	53.5	16.8	2.69	17.1	5.6	1.52	25	28	27	32
8"	5¼	17	5.00	8	5 1/4	5/16	1/4	6 3/4	5/8	3/16	2 1/2	2 1/4	56.4	14.1	3.36	6.7	2.6	1.16	21	24	24	23
		20	5.88	8 1/8	5 1/4	3/8	1/4	6 3/4	11/16	3/16	2 1/2	2 1/4	69.2	17.0	3.43	8.5	3.2	1.20	26	28	26	25
	6½	24	7.06	7 7/8	6 1/2	3/8	1/4	6 3/8	13/16	3/16	3 1/8	2 1/4	82.5	20.8	3.42	18.2	5.6	1.61	31	35	25	25
		28	8.23	8	6 1/2	7/16	5/16	6 3/8	13/16	1/4	3 1/8	2 1/4	97.8	24.3	3.45	21.6	6.6	1.62	37	40	30	29
	8	31	9.12	8	8	7/16	5/16	6 3/8	13/16	1/4	3 7/8	2 1/4	109.7	27.4	3.47	37.0	9.2	2.01	41	46	30	30
		35	10.30	8 1/8	8	1/2	5/16	6 3/8	7/8	1/4	3 7/8	2 1/4	126.5	31.1	3.50	42.5	10.6	2.03	47	52	33	33
		40	11.76	8 1/4	8 1/8	9/16	3/8	6 3/8	15/16	1/4	3 7/8	2 1/4	146.3	35.5	3.53	49.0	12.1	2.04	53	59	39	38
		48	14.11	8 1/2	8 1/8	11/16	7/16	6 3/8	1 1/16	1/4	3 7/8	2 1/2	183.7	43.2	3.61	60.9	15.0	2.08	65	72	45	44
		58	17.06	8 3/4	8 1/4	13/16	1/2	6 3/8	1 3/16	5/16	3 7/8	2 1/2	227.3	52.0	3.65	74.9	18.2	2.10	78	87	58	57
		67	19.70	9	8 1/4	15/16	9/16	6 3/8	1 5/16	3/8	3 7/8	2 3/4	271.8	60.4	3.71	88.6	21.4	2.12	91	101	67	66
10"	5¾	21	6.19	9 7/8	5 3/4	5/16	1/4	8 1/2	11/16	3/16	2 3/4	2	106.3	21.5	4.14	9.7	3.4	1.25	32	36	31	24
		25	7.35	10 1/8	5 3/4	7/16	1/4	8 1/2	13/16	3/16	2 3/4	2 1/4	133.2	26.4	4.26	12.7	4.4	1.31	40	44	33	26
		29	8.53	10 1/4	5 3/4	1/2	5/16	8 1/2	7/8	1/4	2 3/4	2 1/4	157.3	30.8	4.29	15.2	5.2	1.34	46	51	38	30
	8	33	9.71	9 3/4	8	7/16	5/16	7 7/8	15/16	1/4	3 7/8	2 1/4	170.9	35.0	4.20	36.5	9.2	1.94	53	58	37	31
		39	11.48	10	8	1/2	5/16	7 7/8	1 1/16	1/4	3 7/8	2 1/2	209.7	42.2	4.27	44.9	11.2	1.98	63	70	41	35
		45	13.24	10 1/8	8	5/8	3/8	7 7/8	1 1/8	1/4	3 7/8	2 1/2	248.6	49.1	4.33	53.2	13.3	2.00	74	82	46	39
	10	49	14.40	10	10	9/16	3/8	7 7/8	1 1/16	1/4	4 7/8	2 1/2	272.9	54.6	4.35	93.0	18.6	2.54	82	91	44	37
		54	15.88	10 1/8	10	5/8	3/8	7 7/8	1 1/8	1/4	4 7/8	2 1/2	305.7	60.4	4.39	103.9	20.7	2.56	91	101	48	41
		60	17.66	10 1/4	10 1/8	11/16	7/16	7 7/8	1 3/16	5/16	4 7/8	2 1/2	343.7	67.1	4.41	116.5	23.1	2.57	101	112	55	47
		66	19.41	10 3/8	10 1/8	3/4	7/16	7 7/8	1 1/4	5/16	4 7/8	2 1/2	382.5	73.7	4.44	129.2	25.5	2.58	110	123	62	52
		72	21.18	10 1/2	10 1/8	13/16	1/2	7 7/8	1 5/16	5/16	4 7/8	2 3/4	420.7	80.1	4.46	141.8	27.9	2.59	120	133	70	59
		77	22.67	10 5/8	10 1/4	7/8	9/16	7 7/8	1 3/8	3/8	4 7/8	2 3/4	457.2	86.1	4.49	153.4	30.1	2.60	129	143	74	62
		89	26.19	10 7/8	10 1/4	1	5/8	7 7/8	1 1/2	3/8	4 7/8	2 3/4	542.4	99.7	4.55	180.6	35.2	2.63	150	166	87	74
		100	29.43	11 1/8	10 3/8	1 1/8	11/16	7 7/8	1 5/8	7/16	4 7/8	3	625.0	112.4	4.61	206.6	39.9	2.65	169	188	99	84
		112	32.92	11 3/8	10 3/8	1 1/4	3/4	7 7/8	1 3/4	7/16	4 7/8	3	718.7	126.3	4.67	235.4	45.2	2.67	190	210	111	95
12"	6½	27	7.97	12	6 1/2	7/16	1/4	10 3/8	13/16	3/16	3 1/8	2	204.1	34.1	5.06	16.6	5.1	1.44	51	57	37	25
		31	9.12	12 1/8	6 1/2	1/2	1/4	10 3/8	7/8	3/16	3 1/8	2 1/4	238.4	39.4	5.11	19.8	6.1	1.47	59	66	42	28
		36	10.59	12 1/4	6 5/8	9/16	5/16	10 3/8	15/16	1/4	3 1/8	2 1/4	280.8	45.9	5.15	23.7	7.2	1.50	69	77	49	33
	8	40	11.77	12	8	1/2	5/16	9 3/4	1 1/8	1/4	3 7/8	2 1/2	310.1	51.9	5.13	44.1	11.0	1.94	78	86	46	33
		45	13.24	12	8	9/16	3/8	9 3/4	1 3/16	1/4	3 7/8	2 1/2	350.8	58.2	5.15	50.0	12.4	1.94	87	97	53	38
		50	14.71	12 1/4	8 1/8	5/8	3/8	9 3/4	1 1/4	1/4	3 7/8	2 1/2	394.5	64.7	5.18	56.4	14.0	1.96	97	108	59	42
	10	53	15.59	12	10	9/16	3/8	9 3/4	1 3/16	1/4	4 7/8	2 1/2	426.2	70.7	5.23	96.1	19.2	2.48	106	118	54	39
		58	17.06	12 1/4	10	5/8	3/8	9 3/4	1 1/4	1/4	4 7/8	2 1/2	476.1	78.1	5.28	107.4	21.4	2.51	117	130	57	41
	12	65	19.11	12 1/8	12	5/8	3/8	9 3/4	1 3/16	1/4	5 3/4	2 1/2	533.4	88.0	5.28	174.6	29.1	3.02	132	147	61	44
		72	21.16	12 1/4	12	11/16	7/16	9 3/4	1 1/4	5/16	5 3/4	2 1/2	597.4	97.5	5.31	195.3	32.4	3.04	146	162	69	49
		79	23.22	12 3/8	12 1/8	3/4	1/2	9 3/4	1 5/16	5/16	5 3/4	2 3/4	663.0	107.1	5.34	216.4	35.8	3.05	161	178	76	54
		85	24.98	12 1/2	12 1/8	13/16	1/2	9 3/4	1 3/8	5/16	5 3/4	2 3/4	723.3	115.7	5.38	235.5	38.9	3.07	174	193	80	58
		92	27.06	12 5/8	12 1/8	7/8	9/16	9 3/4	1 7/16	3/8	5 3/4	2 3/4	788.9	125.0	5.40	256.4	42.2	3.08	188	208	89	64
		99	29.09	12 3/4	12 1/4	15/16	5/8	9 3/4	1 1/2	3/8	5 3/4	2 3/4	858.5	134.7	5.43	278.2	45.7	3.09	202	224	96	70
		106	31.19	12 7/8	12 1/4	1	5/8	9 3/4	1 9/16	3/8	5 3/4	3	930.7	144.5	5.46	300.9	49.2	3.11	217	241	104	75
		120	35.31	13 1/8	12 3/8	1 1/8	3/4	9 3/4	1 11/16	7/16	5 3/4	3	1071.7	163.4	5.51	345.1	56.0	3.13	245	272	121	88
		133	39.11	13 3/8	12 3/8	1 1/4	3/4	9 3/4	1 13/16	7/16	5 3/4	3 1/4	1221.2	182.5	5.59	389.9	63.1	3.16	274	304	131	96
		161	47.38	13 7/8	12 1/2	1 1/2	15/16	9 3/4	2 1/16	1/2	5 3/4	3 1/2	1541.8	222.2	5.70	486.2	77.7	3.20	333	370	163	121
		190	55.86	14 3/8	12 5/8	1 3/4	1 1/16	9 3/4	2 5/16	5/8	5 3/4	3 3/4	1892.5	263.2	5.82	589.7	93.1	3.25	395	438	198	148
14"	6¾	30	8.81	13 7/8	6 3/4	3/8	5/16	12 1/8	7/8	3/16	3 1/4	2 1/4	289.6	41.8	5.73	17.5	5.2	1.41	63	70	49	28
		34	10.00	14	6 3/4	7/16	5/16	12 1/8	15/16	1/4	3 1/4	2 1/4	339.2	48.5	5.83	21.3	6.3	1.46	73	81	52	31
		38	11.17	14 1/8	6 3/4	1/2	5/16	12 1/8	1	1/4	3 1/4	2 1/4	385.3	54.6	5.87	24.6	7.3	1.49	82	91	58	34
	8	43	12.65	13 5/8	8	1/2	5/16	11 3/8	1 1/8	1/4	3 7/8	2 1/2	429.0	62.7	5.82	45.1	11.3	1.89	94	104	55	34
		48	14.11	13 3/4	8	9/16	3/8	11 3/8	1 3/16	1/4	3 7/8	2 1/2	484.9	70.2	5.86	51.3	12.8	1.91	105	117	61	38
		53	15.59	14	8	11/16	3/8	11 3/8	1 1/4	1/4	3 7/8	2 1/2	542.1	77.8	5.90	57.5	14.3	1.92	117	130	67	42
	10	61	17.94	13 7/8	10	5/8	3/8	11 3/8	1 1/4	1/4	4 3/4	2 1/2	641.5	92.2	5.98	107.3	21.5	2.45	138	154	68	43
		68	20.00	14	10	11/16	7/16	11 3/8	1 5/16	5/16	4 3/4	2 1/2	724.1	103.0	6.02	121.2	24.1	2.46	155	172	76	48
		74	21.76	14 1/4	10 1/8	13/16	7/16	11 3/8	1 3/8	5/16	4 3/4	2 3/4	796.8	112.3	6.05	133.5	26.5	2.48	169	187	83	53
	12	78	22.94	14	12	11/16	7/16	11 3/8	1 5/16	5/16	5 3/4	2 1/2	851.2	121.1	6.09	206.9	34.5	3.00	182	202	78	49
		84	24.71	14 1/8	12	3/4	7/16	11 3/8	1 3/8	5/16	5 3/4	2 3/4	928.4	130.9	6.13	225.5	37.5	3.02	196	218	83	53
	14½	87	25.56	14	14 1/2	11/16	7/16	11 3/8	1 5/16	5/16	7	2 1/2	966.9	138.1	6.15	349.7	48.2	3.70	207	230	76	49
		95	27.94	14 1/8	14 1/2	3/4	1/2	11 3/8	1 3/8	5/16	7	2 3/4	1063.5	150.6	6.17	383.7	52.8	3.71	226	251	85	55
		103	30.26	14 1/4	14 5/8	13/16	1/2	11 3/8	1 7/16	5/16	7	2 3/4	1165.8	163.6	6.21	419.7	57.6	3.72	245	273	92	59
		111	32.65	14 3/8	14 5/8	7/8	9/16	11 3/8	1 1/2	3/8	7	2 3/4	1266.5	176.3	6.23	454.9	67.2	3.73	264	294	101	65
		119	34.99	14 1/2	14 5/8	15/16	9/16	11 3/8	1 9/16	3/8	7	2 3/4	1373.1	189.4	6.26	491.8	67.1	3.75	284	315	107	69
		127	37.33	14 5/8	14 3/4	1	5/8	11 3/8	1 5/8	3/8	7	3	1476.7	202.0	6.29	527.6	71.8	3.76	303	337	116	75
		136	39.98	14 3/4	14 3/4	1 1/16	11/16	11 3/8	1 11/16	7/16	7	3	1593.0	216.0	6.31	567.7	77.0	3.77	324	360	126	82
	15½	142	41.85	14 3/4	15 1/2	1 1/16	11/16	11 3/8	1 11/16	7/16	7 3/8	3	1672.2	226.7	6.32	660.1	85.2	3.97	340	378	130	85
		150	44.08	14 7/8	15 1/2	1 1/8	11/16	11 3/8	1 3/4	7/16	7 3/8	3	1786.9	240.2	6.37	702.5	90.6	3.99	360	401	134	88
		158	46.47	15	15 1/2	1 3/16	3/4	11 3/8	1 13/16	7/16	7 3/8	3	1900.6	253.4	6.40	745.0	95.8	4.00	380	422	142	93
		167	49.09	15 1/8	15 5/8	1 1/4	13/16	11 3/8	1 7/8	7/16	7 3/8	3 1/4	2020.8	267.3	6.42	790.2	101.3	4.01	400	445	153	100
		176	51.73	15 1/4	15 5/8	1 5/16	13/16	11 3/8	1 15/16	1/2	7 3/8	3 1/4	2149.6	281.9	6.45	837.9	107.1	4.02	422	470	162	107
		184	54.07	15 3/8	15 5/8	1 3/8	7/8	11 3/8	2	1/2	7 3/8	3 1/4	2274.8	295.8	6.49	882.7	112.7	4.04	443	493	168	111
		193	56.73	15 1/2	15 3/4	1 7/16	7/8	11 3/8	2 1/16	1/2	7 3/8	3 1/4	2402.4	310.0	6.51	930.1	118.4	4.05	465	517	179	118
		202	59.39	15 5/8	15 3/4	1 1/2	15/16	11 3/8	2 1/8	9/16	7 3/8	3 1/2	2538.8	324.9	6.54	979.7	124.4	4.06	487	541	189	125
		211	62.07	15 3/4	15 3/4	1 9/16	1	11 3/8	2 3/16	9/16	7 3/8	3 1/2	2671.4	339.2	6.56	1028.6	130.2	4.07	508	565	200	133
		219	64.36	15 7/8	15 7/8	1 5/8	1	11 3/8	2 1/4	9/16	7 3/8	3 1/2	2798.2	352.6	6.59	1073.2	135.6	4.08	529	587	207	139
		228	67.06	16	15 7/8	1 11/16	1 1/16	11 3/8	2 5/16	5/8	7 3/8	3 1/2	2942.4	367.8	6.62	1124.8	141.8	4.10	550	612	217	146

WIDE FLANGE SHAPES

1946 SIMPLIFIED LIST

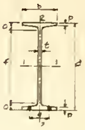
PARALLEL FLANGE

I = Moment of Inertia, in.^{4}
S = Section Modulus, in.^{3}
r = Radius of Gyration, in.
M = Bending Moment, kip ft.
V = Max. Web Shear, kips
R = Max. Reaction, 3½″ bearing, kips
M is given for 18000 and 20000 fiber stress; V for unit shear = 13000



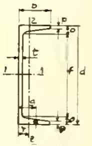
NOM. DEPTH	NOM. WIDTH	WT. PER FOOT	AREA SQ. IN.	Dimensions									Axis 1-1			Axis 2-2			M		V	R
				d	b	p	t	f	o	h	a	g	I	S	r	I	S	r	18000	20000		
14″	16	237	69.69	16⅛	15⅞	1¾	1⅛	11⅜	2⅜	⅝	7⅜	3¾	3080.9	382.2	6.65	1174.8	147.7	4.11	573	638	228	154
		246	72.33	16¼	16	1 13/16	1⅛	11⅜	7 7/16	⅝	7⅜	3¾	3228.9	397.4	6.68	1226.6	153.9	4.12	595	660	238	160
		264	77.63	16½	16	1 15/16	1¼	11⅜	2½	11/16	7⅜	3¾	3526.0	427.4	6.74	1331.7	166.1	4.14	641	712	259	173
		287	84.37	16¾	16⅛	2 1/16	1 5/16	11⅜	2 9/16	¾	7⅜	4	3912.1	465.5	6.81	1466.5	181.8	4.17	697	775	286	190
		314	92.30	17¼	16¼	2 5/16	1 7/16	11⅜	2⅝	13/16	7⅜	4¼	4399.4	511.9	6.90	1631.4	201.0	4.20	766	851	316	208
		320	94.12	16¾	16¾	2 1/16	1⅞	11⅜	2 11/16	1	7⅜	4	4141.7	492.8	6.63	1635.1	195.7	4.17	740	821	412	280
		342	100.59	17½	16⅜	2 7/16	1 9/16	11⅜	3 1/16	⅞	7⅜	4¼	4911.5	559.4	6.99	1806.9	220.8	4.24	838	930	352	243
		370	108.78	18	16½	2 11/16	1 11/16	11⅜	3¼	⅞	7⅜	4½	5454.2	608.1	7.08	1986.0	241.1	4.27	911	1012	386	268
		398	116.98	18¼	16⅝	2 13/16	1 13/16	11⅜	3 7/16	15/16	7⅜	4¾	6013.7	656.9	7.17	2169.7	261.6	4.31	985	1093	420	294
		426	125.25	18¾	16¾	3 1/16	1⅞	11⅜	3⅝	1	7⅜	5	6610.3	707.4	7.26	2359.5	282.7	4.34	1060	1175	455	321
16″	7	36	10.59	15⅞	7	7/16	5/16	14	15/16	¼	3⅜	2¼	446.3	56.3	6.49	22.1	6.3	1.45	84	94	62	32
		40	11.77	16	7	½	5/16	14	1	¼	3⅜	2¼	515.5	64.4	6.62	26.5	7.6	1.50	97	107	64	33
		45	13.24	16⅛	7	9/16	⅜	14	1 1/16	¼	3⅜	2¼	583.3	72.4	6.64	30.5	8.7	1.52	109	121	73	38
		50	14.70	16¼	7⅛	⅝	⅜	14	1⅛	¼	3⅜	2½	655.4	80.7	6.68	34.8	9.8	1.54	121	135	80	42
	8½	58	17.04	15⅞	8½	⅝	7/16	13⅜	1¼	5/16	4	2½	746.4	94.1	6.62	60.5	14.3	1.88	141	157	84	46
		64	18.80	16	8½	11/16	7/16	13⅜	1 5/16	5/16	4	2½	833.8	104.2	6.66	68.4	16.1	1.91	156	174	92	51
		71	20.86	16⅛	8½	13/16	½	13⅜	1⅜	5/16	4	2¾	936.9	115.9	6.70	77.9	18.2	1.93	174	193	102	57
		78	22.92	16⅜	8⅝	⅞	9/16	13⅜	1½	5/16	4	2¾	1042.6	127.8	6.74	87.5	20.4	1.95	192	213	112	64
	11½	88	25.87	16⅛	11½	13/16	½	13⅛	1½	5/16	5½	2¾	1222.6	151.3	6.87	185.2	32.2	2.67	227	252	106	61
		96	28.22	16⅜	11½	⅞	9/16	13⅛	1⅝	⅜	5½	2¾	1355.1	166.1	6.93	207.2	35.9	2.71	249	277	114	66
18″	7½	50	14.71	18	7½	9/16	⅜	15⅞	1 1/16	¼	3⅝	2¼	800.6	89.0	7.38	37.2	9.9	1.59	134	148	84	39
		55	16.19	18⅛	7½	⅝	⅜	15⅞	1⅛	¼	3⅝	2½	889.9	98.2	7.41	42.0	11.1	1.61	147	164	92	43
		60	17.64	18¼	7½	¾	7/16	15⅞	1 3/16	5/16	3⅝	2½	984.0	107.8	7.47	47.1	12.5	1.63	162	179	99	47
	8¾	64	18.80	17⅞	8¾	11/16	7/16	15⅜	1¼	¼	4⅛	2½	1045.8	117.0	7.46	70.3	16.1	1.93	176	195	94	46
		70	20.56	18	8¾	¾	7/16	15⅜	1 5/16	5/16	4⅛	2¾	1153.9	128.2	7.49	78.5	17.9	1.95	192	214	103	51
		77	22.63	18⅛	8¾	13/16	½	15⅜	1⅜	5/16	4⅛	2¾	1286.8	141.7	7.54	88.6	20.2	1.98	213	236	112	56
		85	24.97	18⅜	8⅞	15/16	9/16	15⅜	1½	5/16	4⅛	2¾	1429.9	156.1	7.57	99.4	22.5	2.00	234	260	125	63
	11¾	96	28.22	18⅛	11¾	13/16	½	15⅛	1½	5/16	5⅝	2¾	1674.7	184.4	7.70	206.8	35.2	2.71	277	307	121	62
		105	30.86	18⅜	11¾	15/16	9/16	15⅛	1⅝	⅜	5⅝	2¾	1852.5	202.2	7.75	231.0	39.2	2.73	303	337	132	68
		114	33.51	18½	11⅞	1	⅝	15⅛	1 11/16	⅜	5⅝	3	2033.8	220.1	7.79	256.6	43.2	2.76	330	367	143	74
21″	8¼	62	18.23	21	8¼	⅝	⅜	18⅝	1 3/16	¼	4	2½	1326.8	126.4	8.53	53.1	12.9	1.71	190	211	109	45
		68	20.02	21⅛	8¼	11/16	7/16	18⅝	1¼	5/16	4	2½	1478.3	139.9	8.59	60.4	14.6	1.74	210	233	118	49
		73	21.46	21¼	8¼	¾	½	18⅝	1 5/16	5/16	4	2½	1600.3	150.7	8.64	66.2	16.0	1.76	226	251	126	53
	9	82	24.10	20⅞	9	13/16	½	18	1 7/16	5/16	4¼	2¾	1752.4	168.0	8.53	89.6	20.0	1.93	252	280	135	59
		96	28.21	21⅛	9	15/16	9/16	18	1½	⅜	4¼	2¾	2088.9	197.6	8.60	109.3	24.2	1.97	296	329	158	70
	13	112	32.93	21	13	⅞	9/16	17¾	1⅝	5/16	6¼	3	2620.6	249.6	8.92	289.7	44.6	2.96	374	416	144	65
		127	37.34	21¼	13	1	9/16	17¾	1¾	⅜	6¼	3	3017.2	284.1	8.99	338.6	51.8	3.01	426	473	163	74
		142	41.76	21½	13⅛	1⅛	11/16	17¾	1⅞	7/16	6¼	3	3403.1	317.2	9.03	385.9	58.8	3.04	476	529	184	85
24″	9	76	22.37	23⅞	9	11/16	7/16	21⅜	1¼	5/16	4¼	2½	2096.4	175.4	9.68	76.5	17.0	1.85	263	292	137	50
		84	24.71	24⅛	9	13/16	½	21⅜	1⅜	5/16	4¼	2¾	2364.3	196.3	9.78	88.3	19.6	1.89	294	326	147	55
		94	27.63	24¼	9	⅞	½	21⅜	1 7/16	5/16	4¼	2¾	2683.0	220.9	9.85	102.2	22.6	1.92	331	368	163	61
	12	100	29.43	24	12	¾	½	20⅞	1 9/16	5/16	5¾	2¾	2987.3	248.9	10.08	203.5	33.9	2.63	373	415	146	57
		110	32.36	24⅛	12	⅞	½	20⅞	1⅝	5/16	5¾	2¾	3315.0	274.4	10.12	229.1	38.0	2.66	412	457	160	63
		120	35.29	24¼	12⅛	15/16	9/16	20⅞	1 11/16	⅜	5¾	3	3635.3	299.1	10.15	254.0	42.0	2.68	449	499	176	69
	14	130	38.21	24¼	14	⅞	9/16	20¾	1¾	⅜	6¾	3	4009.5	330.7	10.24	375.2	53.6	3.13	496	551	178	71
		145	42.62	24½	14	1	⅝	20¾	1⅞	⅜	6¾	3¼	4561.0	372.5	10.34	434.3	61.8	3.19	558	620	194	78
		160	47.04	24¾	14⅛	1⅛	11/16	20¾	2	⅜	6¾	3¼	5110.3	413.5	10.42	492.6	69.9	3.23	620	689	211	87
27″	10	94	27.65	26⅞	10	¾	½	24	1 7/16	5/16	4¾	2½	3266.7	242.8	10.87	115.1	23.0	2.04	334	371	171	58
		102	30.01	27⅛	10	13/16	½	24	1 9/16	5/16	4¾	2¾	3604.1	266.3	10.96	129.5	25.9	2.08	400	443	182	63
		114	33.53	27¼	10⅛	15/16	9/16	24	1⅝	⅜	4¾	2¾	4080.5	299.2	11.03	149.6	29.7	2.11	449	499	202	70
	14	145	42.68	26⅞	14	1	⅝	23	1 15/16	⅜	6¾	3¼	5414.3	402.9	11.26	406.9	58.3	3.09	604	672	210	78
		160	47.04	27⅛	14	1 1/16	11/16	23	2 1/16	⅜	6¾	3¼	6018.6	444.5	11.31	458.0	65.3	3.12	666	740	231	88
		177	52.10	27¼	14⅛	1 3/16	¾	23	2⅛	7/16	6¾	3¼	6728.6	492.8	11.36	518.9	73.7	3.16	739	821	257	98
30″	10½	108	31.77	29⅞	10½	¾	9/16	26⅞	1½	⅜	5	2¾	4461.0	299.2	11.85	135.1	25.8	2.06	449	499	212	66
		116	34.13	30	10½	⅞	9/16	26⅞	1 9/16	⅜	5	2¾	4919.1	327.9	12.00	153.2	29.2	2.12	492	547	220	69
		124	36.45	30⅛	10½	15/16	⅝	26⅞	1⅝	⅜	5	3	5347.1	354.6	12.11	169.7	32.3	2.16	532	591	229	72
		132	38.83	30¼	10½	1	⅝	26⅞	1 11/16	⅜	5	3	5753.1	379.7	12.17	185.0	35.1	2.18	570	633	242	77
	15	172	50.65	29⅞	15	1 1/16	11/16	25¾	2 1/16	⅜	7⅛	3¼	7891.5	528.2	12.48	550.1	73.4	3.30	792	880	254	87
		190	55.90	30⅛	15	1 3/16	¾	25¾	2 3/16	7/16	7⅛	3½	8825.9	586.1	12.57	624.6	83.1	3.34	879	977	278	97
		210	61.78	30⅜	15⅛	1 5/16	13/16	25¾	2 5/16	7/16	7⅛	3½	9872.4	649.9	12.64	707.9	93.7	3.38	975	1083	306	108
33″	11½	130	38.26	33⅛	11½	⅞	9/16	29¾	1 11/16	⅜	5½	3	6699.0	404.8	13.23	201.4	35.0	2.29	605	673	249	72
		141	41.51	33¼	11½	15/16	⅝	29¾	1¾	⅜	5½	3	7442.2	446.8	13.39	229.7	39.8	2.35	670	745	262	76
		152	44.71	33½	11⅝	1 1/16	⅝	29¾	1⅞	⅜	5½	3	8147.6	486.4	13.50	256.1	44.3	2.39	730	811	277	82
	15¾	200	58.79	33	15¾	1⅛	¾	28⅝	2 3/16	7/16	7½	3½	11048.2	669.6	13.71	691.7	87.8	3.43	1004	1116	307	98
		220	64.73	33¼	15¾	1¼	13/16	28⅝	2 5/16	7/16	7½	3½	12312.1	740.6	13.79	782.4	99.0	3.48	1111	1234	335	108
		240	70.52	33½	15⅞	1⅜	⅞	28⅝	2 7/16	½	7½	3¾	13585.1	811.1	13.88	874.3	110.2	3.52	1217	1352	362	118
36″	12	150	44.16	35⅞	12	15/16	⅝	32¼	1 13/16	⅜	5⅝	3	9012.1	502.9	14.29	250.4	41.8	2.38	754	838	291	80
		160	47.09	36	12	1	11/16	32¼	1⅞	⅜	5⅝	3	9738.8	541.0	14.38	275.4	45.9	2.42	812	902	306	84
		170	49.98	36⅛	12	1⅛	11/16	32¼	1 15/16	7/16	5⅝	3¼	10470.0	579.1	14.47	300.6	50.0	2.45	869	965	320	89
		182	53.54	36⅜	12⅛	1 3/16	¾	32¼	2 1/16	7/16	5⅝	3¼	11281.5	621.2	14.52	327.7	54.3	2.47	932	1035	342	97
		194	57.11	36½	12⅛	1¼	13/16	32¼	2⅛	7/16	5⅝	3¼	12103.4	663.6	14.56	355.4	58.7	2.49	995	1106	365	104
	16½	230	67.73	35⅞	16½	1¼	¾	31⅛	2⅜	7/16	7⅞	3½	14988.4	835.5	14.88	870.9	105.7	3.59	1253	1393	357	108
		245	72.03	36	16½	1⅜	13/16	31⅛	2 7/16	7/16	7⅞	3½	16092.2	892.5	14.95	944.7	114.4	3.62	1338	1486	376	114
		260	76.56	36¼	16½	1 7/16	⅞	31⅛	2 9/16	½	7⅞	3¾	17233.8	951.1	15.00	1020.6	123.3	3.65	1427	1585	398	123
		280	82.32	36½	16⅝	1 9/16	⅞	31⅛	2 11/16	½	7⅞	4	18819.3	1031.2	15.12	1127.5	135.9	3.70	1547	1719	420	132
		300	88.17	36¾	16⅝	1 11/16	15/16	31⅛	2 13/16	9/16	7⅞	4	20290.2	1105.1	15.17	1225.2	147.1	3.73	1658	1842	451	143

AMERICAN STANDARD BEAMS



NOM. DEPTH	WT. PER FOOT	AREA SQ. IN.	Dimensions							Axis 1-1			Axis 2-2			M		V	R
			d	b	p	t	f	o	g₁	I	S	r	I	S	r	18000	20000		
3″	5.7	1.64	3	2 3/8	1/4	3/16	1 7/8	9/16	1 1/2	2.5	1.7	1.23	0.46	0.40	0.53	2.6	2.8	6.9	4080
	7.5	2.17	3	2 1/2	1/4	3/8	1 7/8	9/16	1 1/2	2.9	1.9	1.15	0.59	0.47	0.52	2.9	3.2	14.0	
4″	7.7	2.21	4	2 5/8	5/16	3/16	2 3/4	5/8	1 1/2	6.0	3.0	1.64	0.77	0.58	0.59	4.5	5.0	10	
	9.5	2.76	4	2 3/4	5/16	5/16	2 3/4	5/8	1 1/2	6.7	3.3	1.56	0.91	0.65	0.58	5.0	5.5	18	
5″	10.0	2.87	5	3	5/16	1/4	3 5/8	11/16	1 3/4	12.1	4.8	2.05	1.2	0.82	0.65	7.2	8.0	14	
	14.75	4.29	5	3 1/4	5/16	1/2	3 5/8	11/16	1 3/4	15.0	6.0	1.87	1.7	1.0	0.63	9.0	10.0	33	
6″	12.5	3.61	6	3 3/8	5/16	1/4	4 1/2	3/4	2	21.8	7.3	2.46	1.8	1.1	0.72	11	12	19	
	17.25	5.02	6	3 5/8	3/8	1/2	4 1/2	3/4	2	26.0	8.7	2.28	2.3	1.3	0.68	13	15	38	
7″	15.3	4.43	7	3 5/8	3/8	1/4	5 3/8	13/16	2 1/4	36.2	10.4	2.86	2.7	1.5	0.78	16	17	24	
	20.0	5.83	7	3 7/8	3/8	7/16	5 3/8	13/16	2 1/4	41.9	12.0	2.68	3.1	1.6	0.74	18	20	36	
8″	18.4	5.34	8	4	7/16	5/16	6 1/4	7/8	2 1/4	56.9	14.2	3.26	3.8	1.9	0.84	21	24	29	
	23.0	6.71	8	4 1/8	7/16	7/16	6 1/4	7/8	2 1/4	64.2	16.0	3.09	4.4	2.1	0.81	24	27	48	
10″	25.4	7.38	10	4 5/8	1/2	5/16	8	1	2 3/4	122.1	24.4	4.07	6.9	3.0	0.97	37	41	42	
	35.0	10.22	10	5	1/2	5/8	8	1	2 3/4	145.8	29.2	3.78	8.5	3.4	0.91	44	49	80	
12″	31.8	9.26	12	5	1/2	3/8	9 3/4	1 1/8	3	215.8	36.0	4.83	9.5	3.8	1.01	54	60	57	
	35.0	10.20	12	5 1/8	1/2	7/16	9 3/4	1 1/8	3	227.0	37.8	4.72	10.0	3.9	0.99	57	63	69	
	40.8	11.84	12	5 1/4	5/8	1/2	9 3/8	1 5/16	3	268.9	44.8	4.77	13.8	5.3	1.08	67	75	75	
	50.0	14.57	12	5 1/2	5/8	11/16	9 3/8	1 5/16	3	301.6	50.3	4.55	16.0	5.8	1.05	75	84	111	
15″	42.9	12.49	15	5 1/2	9/16	7/16	12 1/2	1 1/4	3 1/2	441.8	58.9	5.95	14.6	5.3	1.08	88	98	83	
	50.0	14.59	15	5 5/8	9/16	9/16	12 1/2	1 1/4	3 1/2	481.1	64.2	5.74	16.0	5.7	1.05	96	107	111	
18″	54.7	15.94	18	6	11/16	1/2	15 1/4	1 3/8	3 1/2	795.5	88.4	7.07	21.2	7.1	1.15	133	148	112	
	70.0	20.46	18	6 1/4	11/16	3/4	15 1/4	1 3/8	3 1/2	917.5	101.9	6.70	24.5	7.8	1.09	153	170	172	
20″	65.4	19.08	20	6 1/4	3/4	1/2	16 7/8	1 9/16	3 1/2	1169.5	116.9	7.83	27.9	8.9	1.21	175	195	135	
	75.0	21.90	20	6 3/8	13/16	5/8	16 7/8	1 9/16	3 1/2	1263.5	126.3	7.60	30.1	9.4	1.17	189	211	173	
	85.0	24.80	20	7	7/8	11/16	16 1/2	1 3/4	4	1501.7	150.2	7.78	47.0	13.3	1.38	225	250	177	
	95.0	27.74	20	7 1/4	15/16	13/16	16 1/2	1 3/4	4	1599.7	160.0	7.59	50.5	14.0	1.35	240	267	216	
24″	79.9	23.33	24	7	7/8	1/2	20 3/4	1 5/8	4	2087.2	173.9	9.46	42.9	12.2	1.36	261	290	162	
	90.0	26.30	24	7 1/8	7/8	5/8	20 3/4	1 5/8	4	2230.1	185.8	9.21	45.5	12.8	1.32	279	310	203	
	100.0	29.25	24	7 1/4	7/8	3/4	20 3/4	1 5/8	4	2371.8	197.6	9.05	48.4	13.4	1.29	296	330	242	
	105.9	30.98	24	7 7/8	1 1/8	5/8	20 1/8	1 15/16	4	2811.5	234.3	9.53	78.9	20.0	1.60	351	390	202	
	120.0	35.13	24	8	1 1/8	13/16	20 1/8	1 15/16	4	3010.8	250.9	9.26	84.9	21.1	1.56	376	418	258	

AMERICAN STANDARD CHANNELS



NOM. DEPTH	WT PER FOOT	AREA SQ. IN.	Dimensions							Axis 1-1			Axis 2-2				M		V	R
			d	b	p	t	f	o	g₁	I	S	r	I	S	r	y	18000	20000		
3″	4.1	1.19	3	1 3/8	1/4	3/16	1 3/4	5/8	7/8	1.6	1.1	1.17	0.20	0.21	0.41	0.44	1.7	1.8	6.9	
	5.0	1.46	3	1 1/2	1/4	1/4	1 3/4	5/8	7/8	1.8	1.2	1.12	0.25	0.24	0.41	0.44	1.8	2.0	10	
	6.0	1.75	3	1 5/8	5/16	3/8	1 3/4	5/8	7/8	2.1	1.4	1.08	0.31	0.27	0.42	0.46	2.1	2.3	14	
4″	5.4	1.56	4	1 5/8	1/4	3/16	2 3/4	5/8	1	3.8	1.9	1.56	0.32	0.29	0.45	0.46	2.9	3.2	10	
	7.25	2.12	4	1 3/4	5/16	5/16	2 3/4	5/8	1	4.5	2.3	1.47	0.44	0.35	0.46	0.46	3.5	3.8	17	
5″	6.7	1.95	5	1 3/4	5/16	3/16	3 5/8	11/16	1 1/8	7.4	3.0	1.95	0.48	0.38	0.50	0.49	4.5	5.0	13	
	9.0	2.63	5	1 7/8	5/16	5/16	3 5/8	11/16	1 1/8	8.8	3.5	1.83	0.64	0.45	0.49	0.48	5.3	5.8	22	
6″	8.2	2.39	6	1 7/8	5/16	3/16	4 1/2	3/4	1 1/8	13.0	4.3	2.34	0.70	0.50	0.54	0.52	6.5	7.2	16	
	10.5	3.07	6	2	3/8	5/16	4 1/2	3/4	1 1/8	15.1	5.0	2.22	0.87	0.57	0.53	0.50	7.5	8.3	26	
	13.0	3.81	6	2 1/8	3/8	7/16	4 1/2	3/4	1 3/8	17.3	5.8	2.13	1.10	0.65	0.53	0.52	8.7	9.7	35	
7″	9.8	2.85	7	2 1/8	3/8	1/4	5 3/8	13/16	1 1/4	21.1	6.0	2.72	0.98	0.63	0.59	0.55	9	10	20	
	12.25	3.58	7	2 1/4	3/8	5/16	5 3/8	13/16	1 1/4	24.1	6.9	2.59	1.20	0.71	0.58	0.53	10	12	30	
	14.75	4.32	7	2 1/4	3/8	7/16	5 3/8	13/16	1 1/4	27.1	7.7	2.51	1.40	0.79	0.57	0.53	12	13	40	
8″	11.5	3.36	8	2 1/4	3/8	1/4	6 3/8	13/16	1 3/8	32.3	8.1	3.10	1.30	0.79	0.63	0.58	12	14	24	
	13.75	4.02	8	2 3/8	3/8	5/16	6 3/8	13/16	1 3/8	35.8	9.0	2.99	1.50	0.86	0.62	0.56	14	15	33	
	18.75	5.49	8	2 1/2	3/8	1/2	6 3/8	13/16	1 1/2	43.7	10.9	2.62	2.00	1.00	0.60	0.57	16	18	52	
9″	13.4	3.89	9	2 3/8	3/8	1/4	7 1/4	7/8	1 3/8	47.3	10.5	3.49	1.8	0.97	0.67	0.61	16	18	28	
	15.0	4.39	9	2 1/2	7/16	5/16	7 1/4	7/8	1 3/8	50.7	11.3	3.40	1.9	1.0	0.67	0.59	17	19	35	
	20.0	5.86	9	2 5/8	7/16	7/16	7 1/4	7/8	1 1/2	60.6	13.5	3.22	2.4	1.2	0.65	0.59	20	23	54	
10″	15.3	4.47	10	2 5/8	7/16	1/4	8 1/8	15/16	1 1/2	66.9	13.4	3.87	2.3	1.2	0.72	0.64	20	22	32	
	20.0	5.86	10	2 3/4	7/16	3/8	8 1/8	15/16	1 1/2	78.5	15.7	3.66	2.8	1.3	0.70	0.61	24	26	51	
	25.0	7.33	10	2 7/8	7/16	9/16	8 1/8	15/16	1 3/4	90.7	18.1	3.52	3.4	1.5	0.68	0.62	27	30	71	
	30.0	8.80	10	3	7/16	11/16	8 1/8	15/16	1 3/4	103.0	20.6	3.42	4.0	1.7	0.67	0.65	31	34	91	
12″	20.7	6.03	12	3	1/2	5/16	9 7/8	1 1/16	1 3/4	128.1	21.4	4.61	3.9	1.7	0.81	0.70	32	36	45	
	25.0	7.32	12	3	1/2	3/8	9 7/8	1 1/16	1 3/4	143.5	23.9	4.43	4.5	1.9	0.79	0.68	36	40	63	
	30.0	8.79	12	3 1/8	1/2	1/2	9 7/8	1 1/16	1 3/4	161.2	26.9	4.28	5.2	2.1	0.77	0.68	40	45	83	
13″	31.8	9.30	13	4	9/16	3/8	10 3/8	1 5/16	2 1/2	237.5	36.5	5.05	11.6	3.9	1.11	1.01	55	61	66	
	35.0	10.24	13	4 1/8	9/16	7/16	10 3/8	1 5/16	2 1/2	250.7	38.6	4.95	12.5	4.0	1.10	0.99	58	64	78	
	40.0	11.71	13	4 1/8	9/16	9/16	10 3/8	1 5/16	2 1/2	271.4	41.7	4.82	13.9	4.3	1.09	0.97	63	70	98	
	50.0	14.66	13	4 3/8	5/8	13/16	10 3/8	1 5/16	2 1/2	312.9	48.1	4.62	16.7	4.9	1.07	0.98	72	80	138	
15″	33.9	9.90	15	3 3/8	5/8	7/16	12 3/8	1 5/16	2	312.6	41.7	5.62	8.2	3.2	0.91	0.79	63	70	81	
	40.0	11.70	15	3 1/2	5/8	9/16	12 3/8	1 5/16	2	346.3	46.2	5.44	9.3	3.4	0.89	0.78	69	77	105	
	50.0	14.64	15	3 3/4	5/8	3/4	12 3/8	1 5/16	2 1/4	401.4	53.6	5.24	11.2	3.8	0.87	0.80	80	90	145	
18″	42.7	12.48	18	4	5/8	7/16	15 3/8	1 5/16	2 1/2	549.2	61.0	6.64	15.0	4.9	1.10	0.90	91	101	109	
	45.8	13.38	18	4	5/8	1/2	15 3/8	1 5/16	2 1/2	573.5	63.7	6.55	15.8	5.1	1.09	0.89	96	106	122	
	51.9	15.18	18	4 1/8	5/8	5/8	15 3/8	1 5/16	2 1/2	622.1	69.1	6.40	17.1	5.3	1.06	0.87	104	115	146	
	58.0	16.98	18	4 1/4	5/8	11/16	15 3/8	1 5/16	2 1/2	670.7	74.5	6.29	18.5	5.6	1.04	0.88	112	124	170	

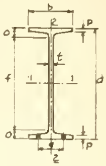
I = Moment of Inertia, in.^{4}
S = Section Modulus, in.^{3}
r = Radius of Gyration, in.
M = Bending Moment, kip ft.
V = Max. Web Shear, kips
R = Max. Reaction, 3½" bearing, kips
M is given for 18000 and 20000 fiber stress; V for unit shear = 13000

MISCELLANEOUS ROLLED SHAPES

PROPERTIES AND DIMENSIONS

1946 SIMPLIFIED LIST

h = ½ web + $\frac{1}{16}$"



LIGHT BEAMS

NOM. DEPTH	NOM. WIDTH	WT. PER FOOT	AREA SQ. IN.	Dimensions									Axis 1-1			Axis 2-2			M		V	R
				d	b	p	t	f	o	h	a	g	I	S	r	I	S	r	18000	20000		
6	4	12	3.53	6	4	1/4	1/4	4 7/8	9/16	3/16	1 7/8	1 3/4	21.7	7.24	2.48	2.89	1.44	.90	11	12	19	
		16	4.72	6 1/4	4	3/8	1/4	4 7/8	11/16	3/16	1 7/8	2	31.7	10.1	2.49	4.32	2.14	.96	15	17	21	
8	4	13	3.83	8	4	1/4	1/4	6 7/8	9/16	3/16	1 7/8	1 3/4	39.5	9.88	3.21	2.62	1.31	.83	15	16	25	
		15	4.43	8 1/8	4	5/16	1/4	6 7/8	5/8	3/16	1 7/8	2	48.0	11.8	3.29	3.30	1.65	.86	18	20	26	
10	4	15	4.40	10	4	1/4	1/4	8 7/8	9/16	3/16	1 7/8	1 3/4	68.8	13.8	3.95	2.79	1.39	.80	21	23	31	
		17	4.98	10 1/8	4	5/16	1/4	8 7/8	5/8	3/16	1 7/8	2	81.8	16.2	4.05	3.45	1.72	.83	24	27	32	
		19	5.61	10 1/4	4	3/8	1/4	8 7/8	11/16	3/16	1 7/8	2	96.2	18.8	4.14	4.19	2.08	.86	28	31	33	
12	4	16 1/2	4.86	12	4	1/4	1/4	10 3/4	5/8	3/16	1 7/8	1 3/4	105.3	17.5	4.65	2.79	1.39	.76	26	29	37	
		19	5.62	12 1/8	4	3/8	1/4	10 3/4	11/16	3/16	1 7/8	2	130.1	21.4	4.81	3.67	1.83	.81	32	36	39	
		22	6.47	12 1/4	4	7/16	1/4	10 3/4	3/4	3/16	1 7/8	2	155.7	25.3	4.91	4.55	2.26	.84	38	42	42	

JOIST

NOM. DEPTH	NOM. WIDTH	WT. PER FOOT	AREA SQ. IN.	Dimensions									Axis 1-1			Axis 2-2			M		V	R
				d	b	p	t	f	o	h	a	g	I	S	r	I	S	r	18000	20000		
6	4	8 1/2	2.50	5 7/8	4	3/16	3/16	5	7/16	3/16	1 7/8	1 3/4	14.8	5.07	2.43	1.89	.96	.87	8	8	14	
8	4	10	2.95	7 7/8	4	3/16	3/16	6 7/8	1/2	3/16	1 7/8	1 3/4	30.8	7.79	3.23	1.99	1.01	.82	12	13	18	
10	4	11 1/2	3.39	9 7/8	4	3/16	3/16	8 7/8	1/2	3/16	1 7/8	1 3/4	51.9	10.5	3.92	2.01	1.02	.77	16	18	24	
12	4	14	4.14	11 7/8	4	1/4	3/16	10 3/4	9/16	3/16	1 7/8	1 3/4	88.2	14.8	4.61	2.25	1.13	.74	22	25	32	

H-BEAMS

NOM. DEPTH	NOM. WIDTH	WT. PER FOOT	AREA SQ. IN.	Dimensions									Axis 1-1			Axis 2-2			M		V	R
				d	b	p	t	f	o	h	a	g	I	S	r	I	S	r	18000	20000		
4	4	10	2.93	4	4	1/4	1/4	2 7/8	9/16	3/16	1 7/8	1 3/4	8.31	4.16	1.68	2.74	1.37	.97	6	7		
		13	3.82	4 1/8	4	3/8	5/16	2 7/8	5/8	3/16	1 7/8	1 3/4	11.3	5.45	1.72	3.76	1.85	.99	8	9	14	
		13.0	3.82	4	4	3/8	1/4	2 1/2	3/4		1 7/8	1 3/4	10.4	5.2	1.65	3.4	1.7	.94	8	9	14	
5	5	18.9	5.47	5	5	7/16	5/16	3 3/8	13/16	1/4	2 3/8	2 1/4	23.8	9.5	2.08	7.8	3.1	1.20	14	16		
6	6	20.0	5.88	6	6	3/8	1/4	4 3/8	13/16	3/16	2 7/8	2 1/4	38.8	12.9	2.57	11.4	3.8	1.39	19	21		
		25.0	7.35	6	6	1/2	5/16	4 1/4	7/8	1/4	2 7/8	2 1/2	47.0	15.7	2.53	14.9	5.0	1.43	23	26		
8	8	34.3	10.09	8	8	7/16	3/8	6 1/4	7/8	1/4	3 7/8	2 1/2	115.5	28.9	3.40	35.1	8.8	1.87	43	48		

JUNIOR BEAMS

NOM. DEPTH	NOM. WIDTH	WT. PER FOOT	AREA SQ. IN.	Dimensions									Axis 1-1			Axis 2-2			M		V	R
				d	b	p	t	f	o	h	a	g	I	S	r	I	S	r	18000	20000		
6	1 7/8	4.4	1.30	6	1 7/8	3/16	1/8	5 1/4	3/8	1/8	7/8	1 1/2	7.3	2.4	2.37	.17	.18	.36	3.6	4.0		
7*	2 1/8	5.5	1.61	7	2 1/8	3/16	1/8	6 1/4	3/8	1/8	1	1 1/2	12.1	3.5	2.74	.25	.24	.39	5.3	5.8		
8	2 1/4	6.5	1.92	8	2 1/4	3/16	1/8	7 1/4	3/8	1/8	1 1/8	1 1/2	18.7	4.7	3.12	.34	.30	.42	7.0	7.8		
9*	2 3/8	7.5	2.20	9	2 3/8	3/16	3/16	8 1/8	7/16	1/8	1 1/8	1 1/2	26.2	5.8	3.45	.39	.33	.42	8.7	9.6		
10	2 3/4	9.0	2.64	10	2 3/4	3/16	3/16	9 1/8	7/16	1/8	1 1/4	1 3/4	39.0	7.8	3.85	.61	.45	.48	11.7	13.0		
11*	2 7/8	10.3	3.01	11	2 7/8	3/16	3/16	10	1/2	3/16	1 3/8	1 3/4	53.1	9.6	4.20	.75	.52	.50	14.4	16.0		
12	3	11.8	3.45	12	3	1/4	3/16	11	1/2	3/16	1 1/2	1 3/4	72.2	12.0	4.57	.98	.64	.53	18.0	20.0		

LIGHTWEIGHT CHANNELS

NOM. DEPTH	NOM. WIDTH	WT. PER FOOT	AREA SQ. IN.	Dimensions									Axis 1-1			Axis 2-2			M		V	R
				d	b	p	t	f	o	h	a	g	I	S	r	I	S	r	18000	20000		
10	1 1/2	6.5	1.91	10	1 1/8	13/32	5/32	9 1/4	3/8	1/4	1 3/32	1 1/2	22.1	4.4	3.47	.12	.13	.25	6.6	7.3		
		8.4	2.47	10	1 1/2	1/4	3/16	9	1/2	1/4	1 3/8	1 3/4	32.3	6.5	3.61	.33	.28	.27	9.7	10.8		
12	1 1/2	10.6	3.12	12	1 1/2	5/16	3/16	10 3/4	5/8	1/4	1 1/4	2	55.8	9.3	4.23	.39	.32	.35	14.0	15.5		

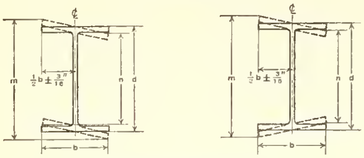
H-BEARING PILE

NOM. DEPTH	NOM. WIDTH	WT. PER FOOT	AREA SQ. IN.	Dimensions									Axis 1-1			Axis 2-2			M		V	R
				d	b	p	t	f	o	h	a	g	I	S	r	I	S	r	18000	20000		
8	8	36	10.60	8	8 1/8	7/16	7/16						119.8	29.9	3.36	40.4	9.9	1.95	45	50		
10	10	42	12.35	9 3/4	10	7/16	7/16						210.8	43.4	4.13	71.4	14.2	2.40	65	72		
		57	16.76	10	10 1/4	9/16	9/16						294.7	58.9	4.19	100.6	19.7	2.45	88	98		
12	12	53	15.58	11 3/4	12	7/16	7/16						394.8	67.0	5.03	127.3	21.2	2.86	101	112		
		74	21.76	12 1/8	12 1/4	5/8	5/8						566.5	93.5	5.10	184.7	30.2	2.91	140	156		
14	14	73	21.46	13 5/8	14 1/2	1/2	1/2						733.1	107.5	5.85	261.9	35.9	3.49	161	178		
		89	26.19	13 7/8	14 5/8	5/8	5/8						909.1	131.2	5.89	326.2	44.4	3.53	197	219		
		102	30.01	14	14 3/4	11/16	11/16						1055.1	150.4	5.93	379.6	51.3	3.56	226	251		
		117	54.44	14 1/4	14 7/8	13/16	13/16						1228.5	172.6	5.97	443.1	59.5	3.59	258	288		

***Not Rolled.**

ROLLING AND CUTTING TOLERANCES

WF SHAPES


℄
m
$\frac{1}{2}b \pm \frac{3''}{16}$
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n
d
b

Scale of Permissible Tolerances exaggerated for clarity.

ROLLING TOLERANCES

Nominal Depth	Depth d		Width of Flange b		Out of Square or Parallel m minus n	Maximum Depth at any Point m	Web off Center
	+	−	+	−			
Up to 12" incl.	1/8"	1/8"	1/4"	3/16"	Not more than 3/16"	Not more than 1/4" over theoretical	Not more than 3/16"
Over 12"	1/8"	1/8"	1/4"	3/16"	Not more than 1/4"	Not more than 1/4" over theoretical	Not more than 3/16"

Shapes may have an allowable variation in weight of plus or minus 2½% from the nominal weight.

CUTTING TOLERANCES

Section	Length in feet				Special Tolerances
	Up to 30 incl.		Over 30		
	+	−	+	−	
Beams 8" to 24" incl.	3/8"	3/8"	3/8" plus 1/16" for each 5' or fraction thereof above 30'	3/8"	When order specifies cutting tolerance "all plus, no minus" (no under-run) the tolerance applying to the ordered length shall be the arithmetical sum of the plus and minus tolerances given in this table.
Beams over 24"	1/2"	1/2"	1/2" plus 1/16" for each 5' or fraction thereof above 30'	1/2"	
Columns all sizes	1/2"	1/2"	1/2" plus 1/16" for each 5' or fraction thereof above 30'	1/2"	

Ends out of square: 1/64" per inch of depth, or flange width if greater than depth.

Allowance for Milling: For material which is to be milled the order should show whether one or both ends are to be milled, allowance added for milling, and whether material is to be cut to standard or special tolerances given above.

It is recommended that material to be milled be ordered in the following lengths:

Milled one end only: Finished length plus 5/8".

Milled both ends: Finished length plus 7/8".

Straightness: Tolerances for beams: $\frac{1}{8}'' \times \frac{\text{total length in feet}}{10'}$

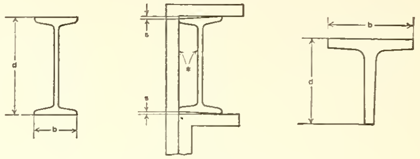
Where sections are specified on orders as columns, the following tolerances will apply:

Lengths up to 45' 0": $\frac{1}{8}'' \times \frac{\text{total length in feet}}{10'}$ but not over 3/8" max.

Lengths over 45' 0": $\frac{3}{8}'' + \frac{1}{8}'' \times \frac{\text{total length}-45'}{10'}$

ROLLING AND CUTTING TOLERANCES

AMERICAN STANDARD BEAMS AND TEES STRUCTURAL SIZES



Scale of Permissible Tolerances exaggerated for clarity.

ROLLING TOLERANCES

Nominal Depth	Depth d		Width of Flanges b		Out of Square or Parallel s + s	Weight	
	+	−	+	−		+	−
3" to 7" incl.	3/32"	1/16"	1/8"	1/8"	1/32" per inch of flange	2½%	2½%
Over 7" to 14" incl.	1/8"	3/32"	5/32"	5/32"		2½%	2½%
Over 14" to 24" incl.	3/16"	1/8"	3/16"	3/16"		2½%	2½%

CUTTING TOLERANCES

Section	Up to 30' incl.		Over 30' to 40' incl.		Over 40' to 50' incl.		Over 50'	
	Over	Under	Over	Under	Over	Under	Over	Under
Structural Beams	3/8"	3/8"	5/8"	3/8"	7/8"	3/8"	1"	3/8"
Structural Tees	3/4"	0	1"	0	1¼"	0	1¼"	0

Ends out of square: 1/64" per inch of depth.

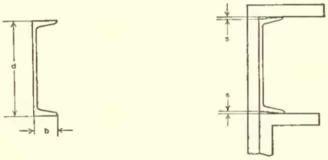
Camber tolerance: $\frac{1}{8}'' \times \frac{\text{total length in feet}}{5'}$

Weight tolerances are based on each shipment consisting of carload lots or fraction thereof of the same figured or ordered weight per linear foot.

*Back of square and web to be parallel when measuring for "out of square."

ROLLING AND CUTTING TOLERANCES

AMERICAN STANDARD CHANNELS CARBUILDING AND SHIPBUILDING CHANNELS (STRUCTURAL SIZES)



Scale of Permissible Tolerances exaggerated for clarity.

ROLLING TOLERANCES

Nominal Depth	Depth d		Width of Flanges b		Out of Square or Parallel s + s	Weight	
	+	−	+	−		+	−
3" to 7" incl.	3/32"	1/16"	1/8"	1/8"	1/32" per inch of flange	2½%	2½%
Over 7" to 14" incl.	1/8"	3/32"	1/8"	5/32"		2½%	2½%
Over 14" to 18" incl.	3/16"	1/8"	1/8"	3/16"		2½%	2½%

CUTTING TOLERANCES

Section	Up to 30' incl.		Over 30' to 40' incl.		Over 40' to 50' incl.		Over 50'	
	Over	Under	Over	Under	Over	Under	Over	Under
Structural	3/8"	3/8"	5/8"	3/8"	7/8"	3/8"	1"	3/8"

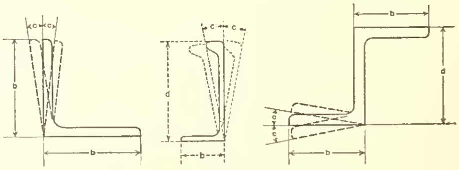
Ends out of square: 1/64" per inch of depth.

Camber tolerance: $\frac{1}{8}'' \times \frac{\text{total length in feet}}{5'}$

Weight tolerances are based on each shipment consisting of carload lots or fraction thereof of the same figured or ordered weight per linear foot.

ROLLING AND CUTTING TOLERANCES

ANGLES, BULB ANGLES AND ZEES (STRUCTURAL SIZES)



Scale of Permissible Tolerances exaggerated for clarity.

ROLLING TOLERANCES

Size-Length of Leg	Thickness	Depth of Section d		Length of Leg b		Out of Square c	Weight	
		+	−	+	−		+	−
3" to 4" incl.	All	1/8"	1/16"	1/8"	3/32"	1½°, or 3/128" per inch of leg length	2½%	2½%
Over 4" to 6" incl.	All	1/8"	1/16"	1/8"	1/8"		2½%	2½%
Over 6"	All	1/8"	1/16"	3/16"	1/8"		2½%	2½%

CUTTING TOLERANCES

Section	Thickness	Up to 30' incl.		Over 30' to 40' incl.		Over 40'	
		Over	Under	Over	Under	Over	Under
Structural	All	3/4"	0	1"	0	1¼"	0

Ends out of square—For Angles and Bulb Angles 1½ degrees, or 3/128" per inch of leg length.

For Zees 1½ degrees, or 3/128" per inch of sum of leg lengths.

Camber tolerance: $\frac{1}{8}'' \times \frac{\text{total length in feet}}{5'}$

Weight tolerances are based on each shipment consisting of carload lots or fraction thereof of the same figured or ordered weight per linear foot.

Longer leg of unequal leg angle determines size for tolerances.

PLATES

TABLES OF AVAILABLE SIZES

Note to Tables I and II: The first length given is obtainable from most, and usually from all, of the mills rolling the given width. The second length given is the maximum obtainable from any mill, and such lengths are subject to substantial extras. For plates of large sizes, designers should consult fabricators regarding possibilities of fabrication, shipment and erection.

TABLE I

Length, in Feet, of Universal Mill Plates obtainable in the respective widths shown.

Thickness Inches	Width, Inches 6-12	13-20	21-26	27-30	31-36	37-42	43-46	47-48	49-58	59-60
¼	65-80	60-125	60-125	60-125	60-125	40-100	90-100	90-100	40- 65	60-
⅜	65-80	60-125	60-125	60-125	60-125	60-125	90-125	90-125	80- 90	70-
½	65-80	60-125	60-125	60-125	60-125	60-125	90-125	90-120	85-120	60-
¾	65-80	60-125	60-125	60-125	60-125	55-125	90-125	90-120	80-120	40-
1	65-80	60-125	60-125	60-125	60-125	40-125	90-125	90- 95	70- 95	40-
1¼	65-75	48-125	48-125	49-125	49-125	38-125	90-115	75- 90	60- 75	40-
1½	40-60	48-120	46-125	46-125	45-125	33-105	90- 95	65- 90	50- 65	35-
1¾	35-60	41-110	40-125	40-125	38-110	28- 90	80- 90	55- 90	45- 55	30-
2	30-60	36- 90	35-125	35-110	34- 95	24- 75	70- 90	45- 90	40- 45	25-
No. of mills from which obtainable	5	7	7	5	6	4	3	3	1	1

TABLE II

Length, in Feet, of Sheared Plates obtainable in the respective widths shown.

Thickness Inches	Width, Inches 24-36	37-48	49-60	61-78	79-96	97-114	115-132	133-150	151-168	169-186
¼	40-45	40-50	40-50	35-55	30-48	27-38	21-30			
⅜	38-50	40-70	40-70	35-70	30-65	30-52	26-48	17-30	24-	21-
½	36-50	40-70	40-70	35-70	30-70	30-55	36-50	20-37	33-	27-
¾	36-50	37-70	35-70	35-70	30-70	30-55	35-48	19-45	45-	39-
1	36-50	34-70	30-70	32-70	25-66	25-53	35-48	18-45	45-	41-
1¼	30-50	30-70	25-70	25-65	20-60	20-45	31-45	17-45	42-	38-
1½	25-40	30-70	23-60	21-60	16-56	15-45	30-45	16-42	41-	33-
1¾	25-40	30-60	22-52	18-59	14-50	12-45	28-44	15-42	40-	31-
2	20-35	25-55	20-49	16-52	13-47	11-45	24-43	14-42	39-	29-
No. of mills from which obtainable	14	14	14	12	12	11	9	5	1	1

FLOOR PLATES—RAISED PATTERN

Different mills offer floor plates in different styles, patterns and extreme dimensions. The nominal or ordered thickness is that of the flat plate exclusive of the height of the raised pattern. The usual weights are as follows:

Nominal Thickness Inches	⅛	$\frac{3}{16}$	¼	$\frac{5}{16}$	⅜	$\frac{7}{16}$	½	⅝	¾
Nominal Weight Lb. per sq. ft.	6.15	8.7	11.25	13.8	16.35	18.9	21.45	26.55	31.65

In general, lengths are limited to 10 feet for widths of 6 to 20 inches and 20 feet for widths of 20 to 72 inches. For longer or thicker plates, and for precise information on all the foregoing, the individual manufacturers should be consulted.

CAMBERING OF ROLLED BEAMS

The following information covers the limitations upon cold cambering of deep beams at the mill, as offered by the American mills which produce wide flange sections.

Maximum length for cambering is 100 feet.

Maximum camber measured at mid-length is shown in the table below. Conversely, this table may be read to give the minimum length for a given camber.

Section	Maximum Camber for Given Length 25′	30′	35′	40′	45′	50′	55′	60′	65′	70′	75′	80′	85′
24″ Wide Flange and Over		1″	1½″	2″	2½″	3″	3½″	3¾″	4″	4¼″	4½″	4¾″	5″
21″ Wide Flange 24″ Standard	1″	1½″	2″	2½″	3″	3½″	3¾″	4″	4¼″	4½″	4¾″	5″	

Camber will approximate a simple regular curve from end to end (nearly) of beam, or between any two points on beam as specified. Reverse or other compound curves will not be undertaken. Camber shall be specified by the ordinate at mid-length of the portion specified to be curved. Ordinates at other points shall not be specified. The cambered ordinate may vary from that specified by ½ inch over, nothing under.

Camber is secured by gagging beams cold. Extremely small cambers may not be permanent and the beam may lose camber due to the release of stresses put into the beam during the camber operation. Minimum camber likely to remain permanent is indicated in table below.

Wide Flange Sections	Minimum Camber Likley to Remain Permanent 30′ Length	35′ Length	40′ Length	45′ Length	50′ Length	55′ Length	65′ Length	75′ Length	85′ Length
36″	½″	½″	¾″	1″	1¼″	1½″	2¼″	3″	3¾″
33″	½″	¾″	1″	1¼″	1½″	1¾″	2½″	3¼″	4″
30″	½″	¾″	1″	1¼″	1½″	2″	2¾″	3½″	4½″
27″	¾″	1″	1″	1½″	1¾″	2″	3″	4″	5″
24″	¾″	1″	1¼″	1½″	2″	2½″	3¼″	4½″	5″

Wide Flange Sections and Standard Beams	Minimum Camber Likely to Remain Permanent 25′ Length	30′ Length	35′ Length	40′ Length	45′ Length	50′ Length	60′ Length	70′ Length	80′ Length
21″ WF	½″	¾″	1″	1½″	1¾″	2¼″	3¼″	4½″	5″
24″ Standard	½″	¾″	1″	1¼″	1½″	2″	2¾″	3¾″	5″

While cambers less than shown in this table can be furnished, no guarantee can be given with respect to their permanency.

ROLLED STEEL BEARING PLATES

Rolled steel bearing plates are extensively used for column bases, wall bearing plates, and a variety of other uses.

Since standard sizes are kept in stock, and only simple fabrication is required, shipments can be made promptly.

The smaller and thinner bearing plates, up to and including 2 inches in thickness, are rolled flat and with surfaces sufficiently smooth to receive, without planing, the milled ends of column shafts. Bearing plates 4 inches and under in thickness can be straightened by a press to within the required limits of flatness.

Rolled steel bearing plates of thicknesses greater than 4 inches are likely to be slightly bowed or cambered so that, in order to provide proper bearing surfaces, these plates should be planed on their top surfaces directly under the columns. It will not be necessary to plane the bottom surfaces when the plates rest on concrete foundations, as full bearing contact can be provided with strong cement grout.

When plates over 4 inches thick rest on steel, the top surfaces should be planed for the column bearing and the bottom surfaces planed all over.

Sizes of rolled steel bearing plates required for use as wall bearing plates or column base plates can be determined by the methods given on pages 128 and 129. Allowable loads on column base plates are given on pages 249 to 251.

The tables of permissible variations of dimension of the American Iron and Steel Institute, as given on page 69, Table III, should be consulted when ordering bearing plates for such finished dimensions as are required by the design.

STANDARD ROLLED SIZES

ALL DIMENSIONS IN INCHES

14 x 1¼	20 x 2	28 x 3	36 x 4	44 x 5	52 x 6	60 x 7	66 x 9	78 x 9
14 x 1½	20 x 2½	28 x 3½	36 x 4½	44 x 5½	52 x 6½	60 x 7½	72 x 8	78 x 9½
	20 x 3			44 x 6	52 x 7	60 x 8	72 x 8½	78 x 10
16 x 1½	24 x 2	32 x 3½	40 x 4½	48 x 5½	56 x 6½	66 x 7½	72 x 9	84 x 9½
16 x 2	24 x 2½	32 x 4	40 x 5	48 x 6	56 x 7	66 x 8	72 x 9½	84 x 10
	24 x 3			48 x 6½	56 x 8	66 x 8½	72 x 10	

SECTION MODULI OF BEARING PLATES 1 INCH WIDE FOR THICKNESSES GREATER THAN 1 INCH

Thickness In.	S In.³	Thickness In.	S In.³	Thickness In.	S In.³	Thickness In.	S In.³
1¼	.26	3¼	1.76	5¼	4.59	7¼	8.76
1½	.38	3½	2.04	5½	5.04	7½	9.38
1¾	.51	3¾	2.34	5¾	5.51	7¾	10.01
2	.67	4	2.67	6	6.00	8	10.67
2¼	.84	4¼	3.01	6¼	6.51	8¼	11.34
2½	1.04	4½	3.38	6½	7.04	8½	12.04
2¾	1.26	4¾	3.76	6¾	7.59	8¾	12.76
3	1.50	5	4.17	7	8.17	9	13.50

PERMISSIBLE VARIATIONS IN WEIGHT AND THICKNESS OF ROLLED STEEL STRUCTURAL SHAPES AND PLATES

AMERICAN SOCIETY FOR TESTING MATERIALS: A 7-46

Permissible Variations

(a) One cubic inch of rolled steel is assumed to weigh 0.2833 lb. The cross-sectional area or weight of each structural-size shape shall not vary more than 2.5 per cent. from the theoretical or specified amounts. The thickness or weights of rectangular sheared mill plates and of universal mill plates shall conform to the requirements of Paragraphs (b), (c) and (d).

(b) Plates, when ordered to thickness. No plate shall vary more than 0.01 in. under the thickness specified.

The overweight in each lot[1] of plates in each shipment shall not exceed the amount given in Table I.

(c) Plates, when ordered to weight per square foot. The weight of each lot[1] of plates in each shipment shall not vary from the weight ordered more than the amounts given in Table II.

(d) Plates over 2 in. in thickness. Each plate over 2 in. in thickness shall conform to the permissible variations over ordered thickness given in Table III.

TABLE I. PERMISSIBLE OVERWEIGHTS OF PLATES TWO INCHES AND UNDER IN THICKNESS WHEN ORDERED TO THICKNESS

Specified Thickness, Inches	Permissible Excess in Average Weight of Lots[1] for Widths Given, in Inches, Expressed in Percentage of Nominal Weights 48 and under	Over 48 to 60, excl.	60 to 72, excl.	72 to 84, excl.	84 to 96, excl.	96 to 108, excl.	108 to 120, excl.	120 to 132, excl.	132 to 144, excl.	144 to 168, excl.	168 and over
$\frac{3}{16}$ to ¼, excl.	....	8	9	10	12	14	16	18			
¼ to $\frac{5}{16}$, "	6	7	8	9	10	12	14	16	19		
$\frac{5}{16}$ to ⅜, "	5	6	7	8	9	10	12	14	17	18	
⅜ to $\frac{7}{16}$, "	4.5	5	6	7	8	9	10	12	15	16	18
$\frac{7}{16}$ to ½, "	4	4.5	5	6	7	8	9	10	13	14	16
½ to ⅝, "	4	4	4.5	5	6	7	8	9	11	12	14
⅝ to ¾, "	4	4	4	4.5	5	6	7	8	9	10	12
¾ to 1, "	3.5	4	4	4	4.5	5	6	7	8	9	11
1 to 2, incl.	3.5	3.5	4	4	4	4.5	5	6	7	8	9

Permissible variations in weight for individual plates shall be one and one-third times the amounts prescribed in this table.

Permissible variation under specified thickness, 0.01 in.

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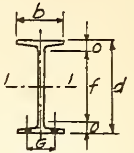
[1] The term "lot" as applied to Table I means all the plates of each group width and group thickness represented in each shipment.

I = Moment of Inertia.
S = Section Modulus.
r = Radius of Gyration.

BETHLEHEM JOIST

A. I. S. C. SPEC.

PROPERTIES AND DIMENSIONS



SIZE JOIST	WT. PER FT. LBS.	DEPTH IN.	FLANGE WIDTH IN.	WEB THICK. IN.	AREA SQ. IN.	Axis 1-1			Axis 2-2			Dimensions					MOMENT FT. LBS.	SHEAR VALUE	BUCKLING LBS. SQ. IN.	VALUE STD. CONN. LBS.	WEIGHT STD CONN. LBS.
						I	S	r	I	S	r	c	f	o	GRIP	G					
6	12.0	6.00	4.000	.230	3.53	21.7	7.24	2.48	2.89	1.44	.90	$5\frac{3}{8}$	$4\frac{15}{16}$	$\frac{9}{16}$	$\frac{1}{4}$	$2\frac{1}{4}$	10860	16560	15000	10400	6
	14.0	6.12	4.015	.245	4.11	26.4	8.63	2.54	3.57	1.78	.93	$5\frac{3}{8}$	$4\frac{15}{16}$	$\frac{5}{8}$	$\frac{5}{16}$	$2\frac{1}{4}$	12950	17990	15000	11000	6
	16.0	6.25	4.030	.260	4.72	31.7	10.1	2.59	4.32	2.14	.96	$5\frac{3}{8}$	$4\frac{15}{16}$	$\frac{11}{16}$	$\frac{3}{8}$	$2\frac{1}{4}$	15220	19500	15000	11700	6
8	13.0	8.00	4.000	.230	3.83	39.5	9.88	3.21	2.62	1.31	.83	$7\frac{7}{16}$	$6\frac{7}{8}$	$\frac{9}{16}$	$\frac{1}{4}$	$2\frac{1}{4}$	14830	22080	14980	10400	9
	15.0	8.12	4.015	.245	4.43	48.0	11.8	3.29	3.30	1.65	.86	$7\frac{7}{16}$	$6\frac{7}{8}$	$\frac{5}{8}$	$\frac{5}{16}$	$2\frac{1}{4}$	17730	23870	15000	11000	9
10	15.0	10.00	4.000	.230	4.40	68.8	13.8	3.95	2.79	1.39	.80	$9\frac{7}{16}$	$8\frac{13}{16}$	$\frac{9}{16}$	$\frac{1}{4}$	$2\frac{1}{4}$	20630	27600	13690	10400	9
	17.0	10.12	4.010	.240	4.98	81.8	16.2	4.05	3.45	1.72	.83	$9\frac{7}{16}$	$8\frac{13}{16}$	$\frac{5}{8}$	$\frac{5}{16}$	$2\frac{1}{4}$	24250	29150	13890	10800	9
	19.0	10.25	4.020	.250	5.61	96.2	18.8	4.14	4.19	2.08	.86	$9\frac{7}{16}$	$8\frac{13}{16}$	$\frac{11}{16}$	$\frac{3}{8}$	$2\frac{1}{4}$	28160	30750	14060	11300	9
12	16.5	12.00	4.000	.230	4.86	105.3	17.5	4.65	2.79	1.39	.76	$11\frac{7}{16}$	$10\frac{13}{16}$	$\frac{9}{16}$	$\frac{1}{4}$	$2\frac{1}{4}$	26310	33120	12380	8280	9
	19.0	12.16	4.010	.240	5.62	130.1	21.4	4.81	3.67	1.83	.81	$11\frac{7}{16}$	$10\frac{13}{16}$	$\frac{11}{16}$	$\frac{3}{8}$	$2\frac{1}{4}$	32100	35020	12610	8640	9
	22.0	12.31	4.030	.260	6.47	155.7	25.3	4.91	4.55	2.26	.84	$11\frac{7}{16}$	$10\frac{13}{16}$	$\frac{3}{4}$	$\frac{7}{16}$	$2\frac{1}{4}$	37950	38410	13100	9360	9

18000 LB. FIBER STRESS
MAXIMUM SPACING FOR VARIOUS LOADS

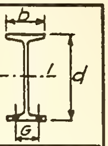
SIZE	SPAN IN FEET	SAFE LOAD. KIPS	Req'd Spacing, in Inches, For Loads Sq. Ft. Shown														
			80	90	100	110	120	130	140	150	160	170	180	190	200	225	250
6″ @ 12#	4	21.7															260
	5	17.4														186	167
	6	14.5												152	145	129	116
	7	12.4									134	125	118	112	106	94	85
	8	10.9					136	126	117	109	102	96	91	86	82	72	65
	9	9.7	162	143	129	117	108	99	93	86	81	76	72	68	65	57	52
	10	8.7	130	116	104	95	87	80	75	70	65	61	58	55	52	46	42
6″ @ 14#	4	25.9															310
	5	20.7															198
	6	17.3													173	153	138
	7	14.8									158	149	141	133	127	113	101
	8	13.0						150	139	130	122	115	108	102	97	87	78
	9	11.5		170	153	139	127	118	109	102	96	90	85	80	76	68	61
	10	10.4	156	138	125	113	104	96	89	83	78	73	69	66	62	55	50
6″ @ 16#	4	30.5															
	5	24.4															234
	6	20.3														180	162
	7	17.4												157	149	132	119
	8	15.2								152	142	134	127	120	114	101	91
	9	13.5					150	138	128	120	112	106	100	95	90	80	72
	10	12.2	183	163	146	133	122	112	104	97	91	86	81	77	73	65	58
8″ @ 13#	6	19.8														176	158
	7	16.9												152	145	128	115
	8	14.8							158	148	139	131	123	117	111	98	89
	9	13.2				160	146	135	126	117	110	103	98	92	88	78	70
	10	11.9		158	143	129	119	110	102	95	89	84	79	75	71	63	57
	11	10.8	147	130	117	107	98	90	84	78	73	69	65	62	58	52	47
	12	9.9	123	110	99	90	82	76	70	66	61	58	55	52	49	44	39
	13	9.1	105	93	84	76	70	64	60	56	52	49	46	44	42	37	33
	14	8.5	91	81	73	66	60	56	52	48	45	43	40	38	36	32	29
8″ @ 15#	6	23.7															189
	7	20.3														155	139
	8	17.7										156	147	139	133	118	106
	9	15.8						162	150	140	131	124	117	111	105	93	84
	10	14.2				155	142	131	122	113	106	100	94	89	85	75	68
	11	12.9		156	141	128	117	108	100	94	88	83	78	74	70	62	56
	12	11.8	147	131	118	107	98	90	84	78	73	69	65	62	59	52	47
	13	10.9	126	112	100	91	84	77	72	67	63	59	56	53	50	44	40
	14	10.1	108	96	87	78	72	66	61	57	54	51	48	45	43	38	34
10″ @ 15#	8	20.6												163	154	137	123
	9	18.3								163	152	143	135	128	122	108	97
	10	16.5					165	152	141	132	123	116	110	104	99	88	79
	11	15.0			164	148	136	126	117	109	102	96	91	86	82	73	65
	12	13.8		153	138	125	115	106	98	92	86	81	76	72	69	61	55
	13	12.7	147	130	117	106	97	90	84	78	73	69	65	61	58	52	47
	14	11.8	126	112	101	92	84	77	72	67	63	59	56	53	50	45	40
	15	11.0	110	98	88	80	73	67	62	58	55	51	49	46	44	39	35
	16	10.3	96	86	77	70	64	59	55	51	48	45	43	40	38	34	31
	17	9.7	85	76	68	62	57	52	49	45	42	40	38	36	34	30	27
	18	9.2	76	68	61	55	51	47	44	41	38	36	34	32	30	27	24
10″ @ 17#	8	24.3														162	145
	9	21.6										169	160	152	144	128	115
	10	19.4							166	155	145	137	129	122	116	103	93
	11	17.6					160	148	137	128	120	113	106	101	96	85	76
	12	16.2			162	147	135	125	115	108	101	95	90	85	81	72	64
	13	14.9		153	137	125	114	106	98	91	86	81	76	72	68	61	55

SIZE	SPAN IN FEET	SAFE LOAD. KIPS	Req'd Spacing, in Inches, For Loads Sq. Ft. Shown														
			80	90	100	110	120	130	140	150	160	170	180	190	200	225	250
10″ @ 17#	14	13.9	149	132	119	108	99	91	85	79	74	70	66	62	59	53	47
	15	12.9	129	114	103	93	86	79	73	68	64	60	57	54	51	45	41
	16	12.1	113	101	91	82	75	70	65	60	56	53	50	47	45	40	36
	17	11.4	100	89	80	73	67	62	57	53	50	47	44	42	40	35	32
	18	10.8	90	80	72	65	60	55	51	48	45	42	40	38	36	32	28
10″ @ 19#	8	28.2															169
	9	25.0													166	148	133
	10	22.5										159	150	142	135	120	108
	11	20.5							160	149	140	131	124	117	111	99	89
	12	18.8					156	145	134	125	117	110	104	99	94	83	75
	13	17.3			160	145	133	123	114	106	100	94	88	84	80	71	63
	14	16.1		153	138	125	115	106	98	92	86	81	76	72	69	61	55
	15	15.0	150	133	120	109	100	92	85	80	75	70	66	63	60	53	48
	16	14.1	132	117	105	96	88	81	75	70	66	62	58	55	52	47	42
	17	13.3	117	104	94	85	78	72	67	62	58	55	52	49	46	41	37
	18	12.5	104	92	83	75	69	64	59	55	52	49	46	43	41	37	33
12″ @ 16½#	10	21.1									158	149	140	133	126	112	101
	11	19.1						160	149	139	130	122	115	109	104	92	83
	12	17.5				159	146	134	125	117	109	103	97	92	87	77	70
	13	16.2		166	149	136	124	115	106	99	93	88	83	78	75	66	59
	14	15.0	161	143	128	117	107	99	92	85	80	75	71	67	64	57	51
	15	14.0	140	124	112	101	93	86	80	74	70	65	62	58	56	49	44
	16	13.2	124	110	99	90	82	76	70	66	62	58	55	52	49	44	39
	17	12.4	109	97	87	79	73	67	62	58	54	51	48	46	43	38	35
	18	11.7	97	86	78	70	65	60	55	52	48	45	43	41	39	34	31
	19	11.1	87	78	70	63	58	54	50	46	43	41	39	37	35	31	28
	20	10.5	78	70	63	57	52	48	45	42	39	37	35	33	31	28	25
	21	10.0	71	63	57	51	47	43	40	38	35	33	31	30	28	25	22
	22	9.6	65	58	52	47	43	40	37	35	32	30	29	27	26	23	21
12″ @ 19#	10	25.7												162	154	137	123
	11	23.3								169	159	149	141	133	127	113	101
	12	21.4						165	153	143	134	126	119	112	107	95	85
	13	19.8				166	152	140	130	122	114	107	101	96	91	81	73
	14	18.3			157	142	131	120	112	104	98	92	87	82	78	69	62
	15	17.1		152	137	124	113	105	97	91	85	80	76	72	68	60	54
	16	16.1	151	134	121	110	101	93	86	80	75	71	67	63	60	53	48
	17	15.1	133	118	106	97	89	82	76	71	66	62	59	56	53	47	42
	18	14.3	119	105	95	86	79	72	67	63	59	55	52	49	47	42	37
	19	13.5	106	94	85	77	71	65	61	56	53	50	47	45	42	37	34
	20	12.8	96	85	76	69	64	59	54	51	48	45	42	40	38	34	30
	21	12.2	87	77	69	63	58	53	49	46	43	41	38	36	34	31	27
	22	11.7	79	71	63	58	53	49	45	42	39	37	35	33	31	28	25
12″ @ 22#	10	30.4														162	146
	11	27.6											167	158	150	134	120
	12	25.3								168	157	148	140	132	126	112	100
	13	23.4						166	154	144	135	127	120	113	108	96	86
	14	21.7					155	143	133	124	116	109	103	98	93	82	74
	15	20.2			161	146	134	124	115	107	101	95	89	85	81	71	64
	16	19.0		158	142	129	118	109	101	95	89	83	79	75	71	63	57
	17	17.9	158	140	126	114	105	97	90	84	79	74	70	66	63	56	50
	18	16.9	140	125	112	102	93	86	80	75	70	66	62	59	56	50	45
	19	16.0	126	112	101	91	84	77	72	67	63	59	56	53	50	45	40
	20	15.2	114	101	91	82	76	78	65	60	57	53	50	48	45	40	36
	21	14.5	103	92	82	75	69	63	59	55	51	48	46	43	41	36	33
	22	13.8	94	83	75	68	62	58	53	50	47	44	41	39	37	33	30
	23	13.2	86	76	68	62	57	53	49	43	43	40	38	36	34	30	27

I = Moment of Inertia.
S = Section Modulus.
r = Radius of Gyration.

J. AND L. JUNIOR BEAMS

A. I. S. C. SPEC.



PROPERTIES AND DIMENSIONS

SIZE JOIST	WEIGHT PER FT. LBS.	DEPTH IN.	WIDTH FLANGE b	WEB THICK. t	AREA SQ. IN.	Axis 1-1			Axis 2-2			GAGE G	GRIP	MAX. HOLE	MOMENT FT. LBS.	TOTAL SHEAR VALUE	UNIT BUCKLING LBS. SQ. IN.	VALUE STD. CONN.	WEIGHT STD. CONN.
						I	S	r	I	S	r								
6	4.4	6.03	1.84	.114	1.30	7.30	2.42	2.37	.165	.179	.357	1⅛	3/16	7/16	3634	8210	12310	5130	4
7	5.5	7.03	2.08	.126	1.61	12.13	3.45	2.74	.248	.239	.393	1⅛	3/16	7/16	5178	10580	11890	5670	5
8	6.5	8.03	2.28	.135	1.92	18.67	4.65	3.12	.343	.301	.423	1⅜	3/16	9/16	6977	12960	11360	6075	5
9	7.5	9.02	2.38	.145	2.20	26.20	5.81	3.45	.394	.332	.423	1⅜	3/16	9/16	8716	15660	10960	6525	5
10	9.0	10.03	2.69	.155	2.64	39.01	7.78	3.85	.608	.452	.480	1⅝	3/16	9/16	11671	18330	10630	6975	5
11	10.3	11.02	2.84	.165	3.01	53.08	9.63	4.20	.746	.525	.498	1¾	3/16	9/16	14444	20930	10340	7425	5
12	11.8	12.03	3.06	.175	3.45	72.21	12.01	4.57	.978	.639	.532	1¾	¼	9/16	18011	23700	10090	7875	5

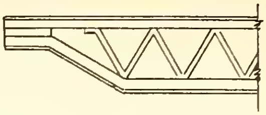
18000 LB. FIBER STRESS
MAXIMUM SPACING FOR VARIOUS LOADS

SIZE	SPAN	TOTAL LOAD PER JOIST	Total Load Per Square Foot, Pounds															
			70	80	90	100	110	115	120	125	130	140	150	160	170	180	190	200
6″ @ 4.4#	8′-0″	3634										39	36¼	34	32	30¼	28¾	27¼
	9′-0″	3230					39¼	37½	36	34½	33¼	30¾	28¾	27	25¼	24	22¾	21½
	10′-0″	2907			38¾	35	31¾	30¼	29	28	26¾	25	23¼	21¾	20½	19½	18¼	17½
	11′-0″	2643		36	32	28¾	26¼	25	24	23	22¼	20½	19¼	18	17	16	15¼	14½
	12′-0″	2423	34½	30¼	27	24¼	22	21	20¼	19½	18¾	17¼	16¼	15¼	14¼	13½	12¾	12
	13′-0″	2236	29½	25¾	23	20¾	18¾	18	17¼	16½	16	14¾	13¾	13	12¼			
	14′-0″	2077	25½	22¼	19¾	17¾	16¼	15½	14¾	14¼	13¾	12¾						
7″ @ 5.5#	10′-0″	4143								39¾	38¼	35½	33¼	31	29¼	27½	26¼	24¾
	11′-0″	3766					37¼	35¾	34¼	32¾	31½	29¼	27½	25¾	24¼	22¾	21½	20½
	12′-0″	3452			38¼	34½	31½	30	28¾	27½	26½	24¾	23	21½	20¼	19¼	18¼	17¼
	13′-0″	3187		36¾	32¾	29½	26¾	25½	24½	23½	22¾	21	19½	18½	17¼	16¼	15½	14¾
	14′-0″	2959	36¼	31¾	28¼	25¼	23	22	21¼	20¼	19½	18	17	15¾	15	14	13¼	12¾
	15′-0″	2762	31½	27½	24½	22	20	19¼	18½	17¾	17	15¾	14¾	13¾	13	12¼		
	16′-0″	2589	27¾	24¼	21½	19½	17¾	17	16¼	15½	15	13¾	13	12¼				
8″ @ 6.5#	11′-0″	5074										39½	37	34½	32½	30¾	29¼	27¾
	12′-0″	4651							38¾	37¼	35¾	33¼	31	29	27¼	25¾	24½	23¼
	13′-0″	4294				39¾	36	34½	33	31¾	30½	28¼	26½	24¾	23¼	22	20¾	19¾
	14′-0″	3987			38	34¼	31	29¾	28½	27¼	26¼	24½	22¾	21¼	20	19	18	17
	15′-0″	3721		37¼	33	29¾	27	26	24¾	23¾	23	21¼	19¾	18½	17½	16½	15¾	15
	16′-0″	3489	37½	32¾	29	26¼	23¾	22¾	21¾	21	20¼	18¾	17½	16¼	15½	14½	13¾	13
	17′-0″	3283	33	29	25¾	23¼	21	20¼	19¼	18½	17¾	16½	15½	14½	13¾	12¾	12¼	
	18′-0″	3101	29½	25¾	23	20¾	18¾	18	17¼	16½	16	14¾	13¾	13	12¼			
9″ @ 7.5#	12′-0″	5811											38¾	36¼	34¼	32¼	30½	29
	13′-0″	5364								39½	38	35¼	33	31	29¼	27½	26	24¾
	14′-0″	4981					38¾	37	35½	34¼	32¾	30½	28½	26¾	25	23¾	22½	21¼
	15′-0″	4648				37¼	33¾	32¼	31	29¾	28½	26½	24¾	23¼	21¾	20¾	19½	18½
	16′-0″	4358			36¼	32¾	29¾	28½	27¼	26¼	25¼	23¼	21¾	20½	19¼	18¼	17¼	16¼
	17′-0″	4102		36¼	32¼	29	26¼	25¼	24¼	23¼	22¼	20¾	19¼	18	17	16	15¼	14½
	18′-0″	3874	37	32¼	28¾	25¾	23½	22½	21½	20¾	19¾	18½	17¼	16¼	15¼	14¼	13½	13
	19′-0″	3670	33	29	25¾	23¼	21	20¼	19¼	18½	17¾	16½	15½	14½	13¾	13	12¼	
	20′-0″	3486	30	26¼	23¼	21	19	18¼	17½	16¾	16	15	14	13	12¼			
10″ @ 9.0#	14′-0″	6669											38	35¾	33½	31¾	30	28½
	15′-0″	6225								39¾	38¼	35½	33¼	31¼	29¼	27¾	26¼	25
	16′-0″	5836					39¾	38	36½	35	33¾	31¼	29¼	27¼	25¾	24¼	23	22
	17′-0″	5492				38¾	35¼	33¾	32¼	31	29¾	27¾	25¾	24¼	22¾	21½	20½	19½
	18′-0″	5187			38½	34½	31½	30	28¾	27¾	26½	24¾	23	21½	20¼	19¼	18¼	17¼
	19′-0″	4914		38¾	34½	31	28¼	27	25¾	24¾	23¾	22¼	20¾	19½	18¼	17¼	16¼	15½
	20′-0″	4668	40	35	31	28	25½	24¼	23¼	22½	21½	20	18¾	17½	16½	15½	14¾	14
	21′-0″	4446	36¼	31¾	28¼	25½	23	22	21¼	20¼	19½	18¼	17	16	15	14	13¼	12¾
	22′-0″	4244	33	29	25¾	23¼	21	20¼	19¼	18½	17¾	16½	15½	14½	13½	12¾	12¼	
11″ @ 10.3#	15′-0″	7704												38½	36¼	34¼	32½	30¾
	16′-0″	7222										38¾	36	33¾	31¾	30	28½	27
	17′-0″	6797							40	38½	37	34¼	32	30	28¼	26¾	25¼	24
	18′-0″	6420					39	37¼	35¾	34¼	33	30½	28½	26¾	25¼	23¾	22½	21½
	19′-0″	6082				38½	35	33½	32	30¾	29½	27½	25½	24	22½	21¼	20¼	19¼
	20′-0″	5778			38½	34¾	31½	30¼	29	27¾	26¾	24¾	23	21¾	20½	19¼	18¼	17¼
	21′-0″	5503		39¼	35	31½	28½	[illegible]	26¼	25¼	24¼	22½	21	19¾	18½	17½	16½	15¾
	22′-0″	5253		35¾	31¾	28¾	26	25	24	23	22	20½	19	18	16¾	16	15	14¼
	23′-0″	5024	37½	32¾	29	26¼	23¾	22¾	21¾	21	20¼	18¾	17½	16½	15½	14½	13¾	13
	24′-0″	4815	34½	30	26¾	24	22	21	20	19¼	18½	17¼	16	15	14¼	13¼	12¾	12
12″ @ 11.8#	16′-0″	9006													39¾	37½	35½	33¾
	17′-0″	8476											40	37½	35¼	33¼	31½	30
	18′-0″	8005										38	35½	33¼	31½	29¾	28	26¾
	19′-0″	7584							40	38¼	36¾	34¼	32	30	28¼	26½	25¼	24
	20′-0″	7204					39¼	37½	36	34½	33¼	30¾	28¾	27	25½	24	22¾	21½
	21′-0″	6861				39¼	35¾	34	32¾	31¼	30¼	28	26¼	24½	23	21¾	20¾	19½
	22′-0″	6549			39¾	35¾	32½	31	29¾	28½	27½	25½	23¾	22¼	21	19¾	18¾	17¾
	23′-0″	6265		40¾	36¼	32¾	29¾	28½	27¼	26¼	25¼	23¼	21¾	20½	19¼	18¼	17¼	16¼
	24′-0″	6004		37½	33¼	30	27¼	26	25	24	23	21½	20	18¾	17¾	16¾	15¾	15
	25′-0″	5764	39½	34½	30¾	27¾	25	24	23	22¼	21	19¾	18½	17¼	16¼	15½	14½	13¾

In accordance with
Design Specifications
of Steel Joist Institute.

OPEN WEB JOIST

ALLOWABLE LOAD TABLES

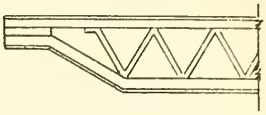


JOIST	SPAN IN FEET	SAFE LOAD, LBS.	Req'd Spacing for Loads per Sq. Ft. Shown														
			80	90	100	110	115	120	125	130	140	150	160	170	180	190	200
81 8″	8	2460								30	28	26	24	23	22	19	18
	9	2180		30	28	26	25	24	23	22	20	19	18	17	16	15	14
	10	1970	30	26	24	22	21	20	19	18	17	16	15	14	13	12	
	11	1780	24	22	19	18	17	16	15	15	14	13	12				
	12	1635	20	18	16	15	14	13	13	12							
	13	1510	17	15	14	13	12										
	14	1400	15	13	12												
82 8″	10	3500									30	28	26	24	23	22	21
	11	3180					30	29	28	26	25	23	22	20	19	18	17
	12	2920			29	26	25	24	23	22	21	19	18	17	16	15	14
	13	2690	30	28	25	23	22	21	20	19	18	16	15	14	14	13	12
	14	2500	26	24	21	20	19	18	17	16	15	14	13	12			
	15	2330	23	21	18	17	16	15	15	14	13	12					
	16	2190	20	18	16	15	14	13	13	12							
102 10″	12	3500					30	29	28	26	25	23	22	20	19	18	17
	13	3230			30	28	26	25	24	23	21	20	19	18	17	16	15
	14	3000	30	28	26	23	22	21	20	20	18	17	16	15	14	13	12
	15	2810	28	25	22	20	19	18	18	17	16	15	14	13	12		
	16	2630	24	22	20	18	17	16	16	15	14	13	12				
	17	2470	22	19	17	16	15	14	14	13	12						
	18	2330	19	17	15	14	13	13	12	12							
	19	2210	17	15	14	13	12										
	20	2100	16	14	12												
103 10″	12	3900								30	28	26	24	23	21	20	19
	13	3900						30	29	28	26	24	22	21	20	19	18
	14	3900				30	29	28	27	26	24	22	21	19	18	17	17
	15	3640			29	26	25	24	23	22	21	19	18	17	16	15	14
	16	3420		28	25	23	22	21	20	19	18	17	16	15	14	13	12
	17	3220	28	25	23	21	20	19	18	17	16	15	14	13	12	12	
	18	3040	25	22	20	19	18	17	16	15	14	13	12	12			
	19	2880	22	20	18	16	16	15	14	14	13	12					
	20	2730	20	18	16	15	14	13	13	12							
104 10″	12	4400										29	28	26	24	23	22
	13	4400								30	29	27	25	24	22	21	20
	14	4400							30	29	27	25	23	22	21	20	19
	15	4400					30	29	28	27	25	23	22	20	19	18	17
	16	4170			30	28	27	26	25	24	22	21	19	18	17	16	15
	17	3920		30	28	25	24	23	22	21	19	18	17	16	15	14	13
	18	3710	30	27	25	23	22	21	20	19	18	16	15	14	14	13	12
	19	3510	28	25	22	20	19	18	18	17	16	15	14	13	12		
	20	3340	25	22	20	18	17	16	16	15	14	13	12				
123 12″	15	4090				30	28	27	26	25	23	22	20	19	18	17	16
	16	3840			29	28	26	25	24	23	22	20	19	18	17	15	14
	17	3610		28	25	23	22	21	20	19	18	17	16	15	14	13	12
	18	3410	28	25	23	21	20	19	18	17	16	15	14	13	13	12	
	19	3230	25	23	20	18	18	17	16	15	14	13	13	12			
	20	3060	23	20	18	17	16	15	15	14	13	12					
	21	2920	21	18	16	15	14	14	13	13	12						
	22	2790	19	17	15	14	13	12	12								
	23	2670	17	15	14	13	12										
	24	2550	16	14	13												
124 12″	15	4600							30	28	26	24	23	21	20	19	18
	16	4600					30	29	28	26	25	23	21	20	19	18	17
	17	4510			30	29	28	26	25	24	23	21	20	19	18	17	16
	18	4260		30	28	26	25	24	23	22	20	19	18	17	16	15	14
	19	4040	30	28	25	23	22	21	20	19	18	17	16	15	14	13	12
	20	3830	28	25	23	21	20	19	18	17	16	15	14	13	12	12	
	21	3650	26	23	21	19	18	17	17	16	15	14	13	12			
	22	3480	24	21	19	17	16	16	15	14	13	12					
	23	3330	22	19	17	16	15	14	14	13	12						
	24	3190	20	18	16	14	14	13	13	12							
125 12″	15	5000								30	28	26	25	23	22	21	20
	16	5000							30	28	26	25	23	22	21	20	19
	17	5000						30	28	27	25	23	22	20	19	18	17
	18	5000					30	29	28	25	24	22	21	19	18	17	16
	19	4990			30	29	28	26	25	24	22	21	20	18	17	16	15
	20	4740		30	28	26	25	24	23	22	20	19	18	17	16	15	14
	21	4510	30	28	26	23	22	21	20	19	18	17	16	15	14	13	13
	22	4300	29	26	23	21	20	19	19	18	17	16	15	14	13	12	
	23	4120	27	24	21	19	19	18	17	16	15	14	13	12	12		
	24	3950	24	22	20	18	17	16	16	15	14	13	12				
126	15	5400									30	28	27	25	24	23	22
	16	5400								30	29	27	25	24	22	21	20

JOIST	SPAN IN FEET	SAFE LOAD, LBS.	Req'd Spacing for Loads per Sq. Ft. Shown														
			80	90	100	110	115	120	125	130	140	150	160	170	180	190	200
126 Con'td 12″	17	5400							30	29	27	25	24	22	21	20	19
	18	5400						30	29	28	26	24	22	21	20	19	18
	19	5400					30	28	27	26	24	22	21	20	19	18	17
	20	5400				30	28	27	26	25	23	21	20	19	18	17	16
	21	5400			30	28	27	26	25	23	22	20	19	18	17	16	15
	22	5300		29	28	26	25	24	23	22	20	19	18	17	16	15	14
	23	5060		28	26	24	23	22	21	20	19	18	17	16	15	14	13
	24	4860	30	26	24	22	21	20	19	18	17	16	15	14	13	12	
145 14″	16	5800										29	27	25	24	23	22
	17	5800									29	27	25	24	22	21	20
	18	5780								30	27	25	24	22	21	20	19
	19	5480					30	29	28	26	25	23	22	20	19	18	17
	20	5200			30	28	27	26	25	24	22	21	19	18	17	16	15
	21	4950		30	28	26	25	24	23	22	20	19	18	17	16	15	14
	22	4730	30	28	26	24	22	21	20	19	18	17	16	15	14	13	13
	23	4520	29	26	23	21	20	19	19	18	17	16	15	14	13	12	
	24	4340	26	24	22	20	19	18	17	16	15	14	13	12	12		
	25	4160	25	22	20	18	17	16	16	15	14	13	12				
	26	4000	23	20	18	17	16	15	15	14	13	12					
	27	3850	21	19	17	16	15	14	13	13	12						
	28	3720	20	18	16	14	14	13	13	12							
146 14″	16	6200										30	29	27	26	24	23
	17	6200										29	27	26	24	23	22
	18	6200									30	27	26	24	23	22	21
	19	6200								30	28	26	24	23	22	20	19
	20	6200							30	29	26	25	23	22	20	19	18
	21	6200						30	28	27	25	23	22	21	20	19	18
	22	6200				30	29	28	27	26	24	22	21	20	19	18	17
	23	5940			30	28	27	26	25	24	22	20	19	18	17	16	15
	24	5690		30	28	26	25	24	23	22	20	19	18	17	16	15	14
	25	5450		29	28	26	23	22	21	20	19	18	17	16	15	14	13
	26	5250	30	27	24	22	21	20	19	18	17	16	15	14	13	13	12
	27	5050	28	25	22	20	19	18	18	17	16	15	14	13	12		
	28	4880	26	23	21	19	18	17	17	16	15	14	13	12			
147 14″	16	6800												30	28	26	25
	17	6800											30	28	26	25	24
	18	6800										30	28	26	25	24	23
	19	6800									30	28	26	25	24	22	21
	20	6800									29	27	25	24	23	21	20
	21	6800								30	28	26	24	23	21	20	19
	22	6800							30	28	26	25	23	22	20	19	18
	23	6800						30	28	27	25	23	22	21	20	19	18
	24	6800					30	28	27	26	24	22	21	20	19	18	17
	25	6560				28	27	26	25	24	22	21	20	19	18	17	16
	26	6300			29	26	25	24	23	22	21	19	18	17	16	15	14
	27	6070		30	27	24	23	22	21	20	19	18	17	16	15	14	13
	28	5850	30	28	25	23	22	21	20	19	18	17	16	15	14	13	12
166 16″	20	6400								29	27	25	24	22	21	20	19
	21	6400						30	29	28	26	24	23	21	20	19	18
	22	6400					30	29	28	27	25	23	22	20	19	18	17
	23	6400				30	29	28	26	25	24	22	21	19	18	17	17
	24	6400				29	28	27	25	24	23	21	20	19	18	17	16
	25	6180			30	27	26	25	24	23	21	20	19	18	17	16	15
	26	5950		30	27	25	24	23	22	21	19	18	17	16	15	14	14
	27	5730		28	25	23	22	21	20	19	18	17	16	15	14	13	12
	28	5520	30	26	24	21	20	20	19	18	17	16	15	14	13	12	
	29	5340	28	24	22	20	19	18	18	17	16	15	14	13	12		
	30	5150	26	23	20	19	18	17	16	15	15	14	13	12			
	31	4990	24	21	19	17	17	16	15	15	14	13	12				
	32	4840	22	20	18	16	15	15	14	14	13	12					
167 16″	20	7200									30	28	26	25	24	23	22
	21	7200									29	27	25	24	23	21	20
	22	7200								30	28	26	24	23	22	20	19
	23	7200							30	29	27	25	23	22	21	20	19
	24	7200						30	29	28	25	24	22	21	20	19	18
	25	7200					30	28	27	26	24	23	21	20	19	18	17
	26	7200				30	29	27	26	25	24	22	20	19	18	17	16
	27	6940			30	28	27	26	24	23	22	20	19	18	17	16	15
	28	6690			28	26	25	24	23	22	20	19	18	17	16	15	14
	29	6460		30	26	24	23	22	21	20	19	18	17	16	15	14	13
	30	6240	30	28	25	23	22	21	20	19	18	17	16	15	14	13	12
	31	6050	29	26	23	21	20	19	19	18	17	16	15	14	13	12	
	32	5860	28	24	22	20	19	18	17	17	16	15	14	13	12		

OPEN WEB JOIST

STEEL JOIST INSTITUTE STANDARD



PROPERTIES AND ALLOWABLE TOTAL LOADS, POUNDS PER LINEAR FOOT

Steel Joist Inst. Designation	SJ81	SJ82	SJ102	SJ103	SJ104	SJ123	SJ124	SJ125	SJ126	SJ145	SJ146	SJ147	SJ166	SJ167	Steel Joist Inst. Designation
Depth, in Inches	8	8	10	10	10	12	12	12	12	14	14	14	16	16	Depth, in Inches
Resisting Moment Inch Kips	29.5	52.5	63.0	82.0	100.0	92.0	115.0	142.0	175.0	156.0	205.0	246.0	232.0	281.0	Resisting Moment Inch Kips
Max. End Reaction in Pounds	1600	1900	1900	1950	2200	2200	2300	2500	2700	2900	3100	3400	3200	3600	Max. End Reaction in Pounds
SPAN 4 FEET	800														SPAN 4 FEET
5	640														5
6	530														6
7	402														7
8	308														8
9	243														9
10	197	350													10
11	162	289													11
12	137	243	292												12
13	116	207	248												13
14	100	178	214												14
15	87	155	187	243		272									15
16	77	137	164	213	260	240									16
17			145	189	230	212									17
18			130	169	205	189	236								18
19			116	151	184	170	212			288					19
20			105	137	167	153	192	237		260					20
21						139	174	215		236					21
22						127	158	196	241	215					22
23						116	145	179	221	197	258				23
24						106	133	164	202	180	237				24
25										166	218	262	247		25
26										154	202	243	229		26
27										143	187	225	212	257	27
28										133	174	209	197	239	28
29													184	223	29
30													172	208	30
31													161	195	31
32													151	183	32

All steel joist, except those having a nailing strip attached, manufactured by Member Companies of the Steel Joist Institute, are in accordance with the foregoing.

Chord sections and web systems of joist vary in properties, areas, weights, etc., at produced by the various companies. For this reason, the weights of the various named joist should be secured from the manufacturer. In all cases, however, the sections provide sufficient area, radius of gyration, etc., to result in a resisting moment equal to that shown in the table, as required by the Steel Joist Institute standards and specifications.

Similarly, while the web systems as manufactured may vary, in all cases they are safe for the maximum end reactions shown.

The allowable load tables are based upon a deflection limitation of $\frac{1}{360}$ of the span.

For unsymmetrical sections, divide proper coefficient by 2n (twice the distance from neutral axis to extreme fiber, in.)

For symmetrical sections, divide proper coefficient by depth of beam, in.

Live load deflection, beams carrying plaster ceiling, should be limited to 1/360 of span.

VERTICAL DEFLECTION

COEFFICIENTS OF DEFLECTION SIMPLE SPAN, UNIFORM LOAD

ASSUMED LATERALLY SUPPORTED

Deflection from equivalent concentrated load at center is 80% of that for U. L.

$$D = \frac{5\,Wl^3}{384\,EI}$$

$$D = \frac{\text{Coefficient}}{2n}$$

D = Deflection, inches
W = Total Uniform Load, lbs.
l = Span, inches
E = 29,000,000
n = Distance, center of gravity to extreme fiber, inches

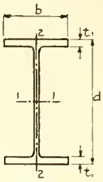
SPAN IN FEET	FIBER STRESS, POUNDS PER SQUARE INCH						
	16,000	18,000	20,000	21,000	22,000	23,000	24,000
1	.0166	.0186	.0207	.0217	.0228	.0238	.0248
2	.0662	.0745	.0828	.0869	.0910	.0951	.0993
3	.1490	.1676	.1862	.1955	.2048	.2141	.2234
4	.2648	.2979	.3310	.3476	.3641	.3807	.3972
5	.4138	.4655	.5172	.5431	.5690	.5948	.6207
6	.5959	.6703	.7448	.7821	.8193	.8566	.8938
7	.8110	.9124	1.0138	1.0645	1.1152	1.1659	1.2166
8	1.0593	1.1917	1.3241	1.3903	1.4566	1.5228	1.5880
9	1.3407	1.5083	1.6759	1.7597	1.8434	1.9272	2.0110
10	1.6552	1.8621	2.0690	2.1724	2.2759	2.3793	2.4828
11	2.0028	2.2531	2.5034	2.6286	2.7558	2.8790	3.0041
12	2.3834	2.6814	2.9793	3.1283	3.2772	3.4262	3.5752
13	2.7972	3.1469	3.4966	3.6714	3.8462	4.0210	4.1959
14	3.2441	3.6497	4.0552	4.2579	4.4607	4.6634	4.8662
15	3.7241	4.1897	4.6552	4.8879	5.1207	5.3534	5.5862
16	4.2372	4.7669	5.2966	5.5614	5.8262	6.0910	6.3559
17	4.7834	5.3814	5.9793	6.2783	6.5772	6.8762	7.1752
18	5.3628	6.0331	6.7034	7.0386	7.3738	7.7090	8.0441
19	5.9752	6.7221	7.4690	7.8424	8.2159	8.5893	8.9628
20	6.6207	7.4483	8.2759	8.6897	9.1034	9.5172	9.9310
21	7.2993	8.2117	9.1241	9.5803	10.0366	10.4928	10.9490
22	8.0110	9.0124	10.0138	10.5145	11.0152	11.5159	12.0166
23	8.7559	9.8503	10.9448	11.4921	12.0393	12.5866	13.1338
24	9.5338	10.7255	11.9172	12.5131	13.1090	13.7048	14.3007
25	10.3448	11.6379	12.9310	13.5776	14.2241	14.8707	15.5172
26	11.1890	12.5876	13.9862	14.6855	15.3848	16.0841	16.7834
27	12.0662	13.5744	15.0828	15.8369	16.5910	17.3452	18.0993
28	12.9766	14.5986	16.2207	17.0317	17.8428	18.6538	19.4648
29	13.9200	15.6600	17.4000	18.2700	19.1400	20.0000	20.8800
30	14.8966	16.7586	18.6207	19.5517	20.4828	21.4138	22.3448
31	15.9062	17.8945	19.8828	20.8769	21.8710	22.8652	23.8593
32	16.9490	19.0676	21.1862	22.2455	23.3048	24.3641	25.4234
33	18.0248	20.2779	22.5310	23.6576	24.7841	25.9107	27.0372
34	19.1338	21.5255	23.9172	25.1131	26.3090	27.5048	28.7007
35	20.2759	22.8103	25.3448	26.6121	27.8793	29.1466	30.4138
36	21.4510	24.1324	26.8138	28.1545	29.4952	30.8359	32.1766
37	22.6593	25.4917	28.3241	29.7403	31.1566	32.5728	33.9890
38	23.9007	26.8883	29.8759	31.3697	32.8634	34.3572	35.8510
39	25.1752	28.3221	31.4690	33.0424	34.6159	36.1893	37.7628
40	26.4828	29.7931	33.1034	34.7586	36.4138	38.0690	39.7241
42	29.1972	32.8469	36.4966	38.3214	40.1462	41.9710	43.7959
44	32.0441	36.0497	40.0552	42.0579	44.0607	46.0634	48.0662
46	35.0234	39.4014	43.7793	45.9683	48.1572	50.3462	52.5352
48	38.1352	42.9021	47.6690	50.0524	52.4359	54.8193	57.2028
50	41.3793	46.5517	51.7241	54.3103	56.8966	59.4828	62.0690
52	44.7559	50.3503	55.9448	58.7421	61.5393	64.3366	67.1338
54	48.2648	54.2979	60.3310	63.3476	66.3641	69.3807	72.3972
56	51.9062	58.3945	64.8828	68.1269	71.3710	74.6152	77.8593
58	55.6800	62.6400	69.6000	73.0800	76.5600	80.0400	83.5200
60	59.5862	67.0345	74.4828	78.2069	81.9310	85.6552	89.3793
65	69.9310	78.6724	87.4138	91.7843	96.1552	100.5259	104.8966
70	81.1034	91.2414	101.3793	106.4483	111.5172	116.5862	121.6552
75	93.1034	104.7414	116.3793	122.1983	128.0172	133.8362	139.6552
80	105.9310	119.1724	132.4138	139.0345	145.6552	152.2759	158.8966
85	119.5862	134.5345	149.4828	156.9569	164.4310	171.9052	179.3793
90	134.0690	150.8276	167.5862	175.9655	184.3448	192.7241	201.1034
95	149.3793	168.0517	186.7241	196.0603	205.3966	214.7328	224.0690
100	165.5172	186.2069	206.8966	217.2414	227.5862	237.9310	248.2759
105	182.4828	205.2931	228.1034	239.5086	250.9138	262.3190	273.7241
110	200.2759	225.3103	250.3448	262.8621	275.3793	287.8965	300.4138

b = Flange Width
d = Depth of Beam
l = Span
t_1 = Flange Thickness
L_u = Max. Span, feet, for which unit stress is 20,000 p.s.i.

LATERAL DEFLECTION OF BEAMS

1946 A.I.S.C. SPECIFICATIONS

For $\frac{ld}{bt_1} = 600$



A unit stress of 20,000 p.s.i. is permitted in laterally unsupported beams so long as the quantity ld/bt_1 does not exceed 600. From this equation the Maximum Spans, for Laterally Unsupported Beams, are tabulated below. When ld/bt_1 exceeds 600, the unit stress must be reduced in accordance with $f = \frac{12{,}000{,}000}{ld/bt_1}$. Thus, the reduced stress for any span in excess of L_u equals 20,000 times the ratio of L_u to the unsupported span. Thus, if unsupported length is twice the critical span, the allowable stress is 20,000 ÷ 2 = 10,000.

WIDE FLANGE BEAMS

d	b	WEIGHT	L_u
4	4	10	13.0
		13	17.0
5	5	16	18.0
		18.5	20.5
6	6	15.5	13.5
		20	18.0
		25	21.5
8	5¼	17	10.0
		20	12.0
	6½	24	16.5
		28	19.0
	8	31	21.5
		35	24.5
		40	27.5
		48	32.5
		58	38.0
		67	43.0
10	5¾	21	10.0
		25	12.5
		29	14.0
	8	33	17.5
		39	21.0
		45	24.5
	10	49	28.0
		54	30.5
		60	33.5
		66	36.0
		72	39.0
		77	41.5
		89	47.0
		100	52.0
		112	57.0
12	6½	27	11.0
		31	12.5
		36	14.5
	8	40	17.0
		45	19.0
		50	21.0
	10	53	24.0
		58	26.5
	12	65	30.0
		72	33.0
		79	36.0
		85	38.5
		92	41.0
		99	44.0
		106	47.0
		120	52.0
		133	57.0
		161	67.0
		190	76.5
14	6¾	30	9.5

WIDE FLANGE BEAMS

d	b	WEIGHT	L_u
14 (CONT.)	6¾	34	11.0
		38	12.5
	8	43	15.5
		48	17.0
		53	19.0
	10	61	23.0
		68	25.5
		74	28.0
	12	78	30.5
		84	33.0
	14½	87	35.3
		95	38.0
		103	41.0
		111	44.0
		119	47.0
		127	50.0
		136	53.0
	16	320	104.0
		142	56.0
		150	59.0
		158	61.5
		167	64.5
		176	67.5
		184	70.0
		193	73.0
		202	75.5
		211	78.5
		219	81.0
		228	84.0
		237	86.0
		246	89.0
		264	94.0
		287	100.0
		314	108.0
		342	115.0
		370	122.0
		398	128.0
		426	135.0
16	7	36	9.5
		40	11.0
		45	12.0
		50	13.5
	8½	58	17.0
		64	19.0
		71	21.0
		78	23.0
	11½	88	28.0
		96	31.0
18	7½	50	12.0
		55	13.0
		60	14.5
	8¾	64	16.5

WIDE FLANGE BEAMS

d	b	WEIGHT	L_u
18 (CONT.)	8¾	70	18.0
		77	20.0
		85	22.0
	11¾	96	27.0
		105	29.0
		114	31.5
21	8¼	62	12.0
		68	13.5
		73	14.5
	9	82	17.0
		96	20.0
	13	112	27.0
		127	30.0
		142	33.5
24	9	76	12.5
		84	14.5
		94	16.0
	12	100	19.0
		110	21.0
		120	23.0
	14	130	26.0
		145	29.0
		160	32.0
27	10	94	13.5
		102	15.0
		114	17.0
	14	145	25.0
		160	27.5
		177	30.5
30	10½	108	13.0
		116	15.0
		124	16.0
		132	17.5
	15	172	26.5
		190	29.5
		210	32.5
33	11½	130	15.0
		141	16.5
		152	18.0
	15¾	200	27.0
		220	30.0
		240	33.0
36	12	150	15.5
		160	17.0
		170	18.0
		182	19.5
		194	20.5
	16½	230	28.5
		245	30.5
		260	32.5
		280	35.5
		300	38.0

STANDARD I-BEAMS

d	b	WEIGHT	L_u
3	2½	5.7	10.0
		7.5	11.0
4	2¾	7.7	9.5
		9.5	10.0
5	3	10.0	10.0
		14.75	10.5
6	3½	12.5	10.0
		17.25	10.5
7	3¾	15.3	10.0
		20.0	11.0
8	4	18.4	10.5
		23.0	11.0
10	5	25.4	11.5
		35.0	12.0
12	5	31.8	11.5
		35.0	11.5
		40.8	14.5
		50.0	15.0
15	5½	42.9	11.0
		50.0	11.5
18	6	54.7	11.5
		70.0	12.0
20	6	65.4	12.0
		75.0	12.5
	7	85.0	16.0
		95.0	16.5
24	7	79.9	12.5
		90.0	13.0
		100.0	13.0
	8	105.9	18.0
		120.0	18.5

MISCELLANEOUS BEAMS

d	b	WEIGHT	L_u
6	J	8.5	6.5
8	J	10	5.0
10	J	11.5	4.0
12	J	14.0	3.5
6	Lb.	12	9.5
		16	13.0
8	Lb.	13	6.5
		15	7.0
10	Lb.	15	5.5
		17	6.5
		19	7.5
12	Lb.	16.5	4.5
		19	5.5
		22	7.0

CHANNELS

d	b	WEIGHT	L_u
3	1½	4.1	6.5
		5.0	7.0
		6.0	7.5
4	1¾	5.4	6.0
		7.25	6.5
5	1¾	6.7	5.5
		9.0	6.0
6	2	8.2	5.5
		10.5	6.0
		13.0	6.0
7	2¼	9.8	5.5
		12.25	5.5
		14.75	6.0
8	2¼	11.5	5.5
		13.75	5.5
		18.75	6.0
9	2½	13.4	5.5
		15.0	5.5
		20.0	6.0
10	2¾	15.3	5.5
		20.0	6.0
		25.0	6.5
		30.0	6.5
12	3	20.7	6.0
		25.0	6.5
		30.0	6.5
15	3½	33.9	7.0
		40.0	7.5
		50.0	8.0
18	4	42.7	6.5
		45.8	7.0
		51.9	7.0
		58.0	7.5

LATERAL DEFLECTION OF BEAMS

1936 A. I. S. C. SPECIFICATIONS

BASED ON $\frac{l}{b}$ RATIOS

Prior to the inclusion of the DeVries theory, in which the ratio of $\frac{ld}{bt}$ was accepted by A. I. S. C. as a criterion for analysis of lateral deflection of steel beams, the older method of considering unsupported beams in terms of l/b was generally used, with an upper limit of $l/b = 40$.

For review purposes the following data, based upon l/b values, is given.

For $\frac{l}{b}$ exceeding 15:

$$\text{All. stress} = \frac{20{,}000}{1 + \frac{l^2}{2{,}000b^2}}$$

l = Unsupported length, comp. flange, in.
b = Width compression flange, in.

18000 LB. MAXIMUM STRESS

ALLOWABLE STRESSES FOR VARIOUS RATIOS $\frac{l}{b}$

$\frac{l}{b}$	TENTHS									
	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
15	18000	17953	17930	17905	17879	17854	17831	17807	17780	17755
16	17730	17705	17680	17654	17629	17604	17577	17552	17527	17501
17	17475	17449	17424	17397	17370	17343	17318	17291	17266	17239
18	17212	17185	17159	17131	17104	17077	17050	17023	16997	16969
19	16942	16915	16888	16859	16832	16805	16776	16749	16722	16695
20	16667	16637	16610	16583	16555	16528	16499	16470	16443	16414
21	16387	16358	16330	16301	16274	16245	16216	16187	16160	16132
22	16103	16074	16045	16016	15988	15959	15932	15903	15874	15845
23	15817	15788	15759	15730	15701	15673	15644	15615	15586	15557
24	15528	15500	15469	15440	15412	15383	15354	15325	15296	15266
25	15238	15208	15179	15151	15122	15093	15064	15035	15007	14976
26	14948	14918	14890	14859	14830	14801	14773	14744	14715	14686
27	14657	14629	14600	14569	14540	14512	14483	14454	14425	14396

$\frac{l}{b}$	TENTHS									
	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
28	14368	14339	14310	14281	14252	14224	14195	14164	14135	14108
29	14080	14051	14022	13993	13964	13936	13907	13878	13849	13820
30	13793	13765	13736	13707	13678	13651	13622	13594	13565	13538
31	13509	13480	13453	13424	13396	13367	13340	13311	13282	13255
32	13228	13199	13171	13144	13115	13088	13059	13032	13005	12976
33	12949	12920	12893	12866	12838	12811	12784	12757	12730	12701
34	12674	12647	12620	12593	12564	12537	12510	12483	12458	12429
35	12403	12377	12350	12323	12296	12269	12242	12215	12190	12163
36	12136	12109	12083	12056	12029	12004	11977	11950	11925	11900
37	11873	11848	11821	11795	11768	11743	11716	11691	11666	11641
38	11614	11588	11563	11536	11513	11486	11461	11435	11410	11385
39	11360	11335	11309	11284	11259	11236	11209	11185	11160	11135
40	11111									

For $\frac{l}{b}$ exceeding 15:

$$\text{All. stress} = \frac{22{,}500}{1 + \frac{l^2}{1{,}800b^2}}$$

l = Unsupported length, comp. flange, in.
b = Width compression flange, in.

20000 LB. MAXIMUM STRESS

ALLOWABLE STRESSES FOR VARIOUS RATIOS $\frac{l}{b}$

$\frac{l}{b}$	TENTHS									
	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
15	20000	19970	19940	19910	19880	19850	19820	19790	19759	19728
16	19699	19668	19637	19606	19575	19544	19513	19482	19450	19419
17	19387	19356	19323	19292	19260	19229	19196	19165	19133	19100
18	19068	19036	19003	18970	18938	18905	18873	18840	18806	18773
19	18741	18708	18675	18641	18609	18575	18543	18510	18476	18443
20	18410	18377	18342	18309	18275	18241	18207	18173	18139	18106
21	18072	18038	18006	17971	17937	17902	17868	17833	17800	17765
22	17732	17697	17664	17629	17595	17560	17526	17492	17458	17424
23	17389	17355	17321	17287	17252	17217	17183	17149	17115	17080
24	17045	17010	16976	16942	16907	16872	16836	16803	16769	16735
25	16701	16667	16632	16598	16564	16529	16494	16460	16426	16391
26	16356	16322	16288	16254	16220	16185	16152	16118	16083	16049
27	16014	15980	15945	15911	15877	15843	15809	15775	15741	15707

$\frac{l}{b}$	TENTHS									
	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
28	15673	15640	15607	15573	15538	15505	15470	15437	15403	15369
29	15335	15302	15269	15235	15201	15167	15133	15100	15066	15033
30	15000	14966	14934	14900	14867	14833	14800	14767	14734	14701
31	14668	14636	14603	14570	14537	14504	14471	14438	14406	14374
32	14341	14308	14277	14244	14212	14179	14147	14115	14083	14051
33	14019	13988	13954	13923	13891	13860	13827	13796	13764	13732
34	13701	13668	13638	13606	13575	13544	13513	13481	13450	13419
35	13388	13357	13326	13295	13265	13235	13204	13174	13143	13112
36	13081	13050	13020	12990	12960	12930	12900	12870	12840	12810
37	12780	12750	12720	12691	12661	12631	12602	12572	12543	12514
38	12485	12456	12427	12398	12368	12341	12310	12281	12252	12224
39	12195	12167	12139	12110	12081	12052	12024	11996	11968	11940
40	11912									

THE LATERAL SUPPORT OF BEAMS

The conditions which cause a compression flange to buckle are usually an unintentional crookedness in the flange or an unintentional eccentricity of load application.

The adoption of, say, a 20000# basic unit stress in any specification presupposes that 20000# is the maximum permissible primary unit stress in any part of the material, and this maximum may be composed of the known stress produced by vertical loading combined with a stress produced by unintentional conditions.

If, for example, a beam carries a stress of 20000#/□″ in one toe of its unsupported compression flange, and the stress resulting from intentional loading is 10000#/□″, the stress resulting from unintentional loading is 20000 — 10000 = 10000#/□″.

With such a beam, if it is desired to apply an intentional load which would produce a unit stress in the compression flange of 20000#/□″, it would be necessary to provide conditions capable of resisting lateral bending which would cause a stress of 10000#/□″ in the extreme fiber of the compression flange. The conditions providing lateral resistance would be passive, since they come into existence only when the vertical load on the beam causes a tendency to buckle laterally; the lateral resistance will be equal to, but will never exceed, the force causing buckling.

If the beam under consideration supports a floor slab or floor system on its compression flange, and can receive its vertical load only from such a floor or the load on such a floor, passive friction must undoubtedly occur between the floor and the beam. This passive friction exists independently of any framed connection between the beam and the floor; the amount of friction can ordinarily never be less than 10%, nor more than 25%, of the load on the beam; the amount of course depends on the friction coefficient. It constitutes a real connection between the beam and the floor, capable of developing the resistive value of the floor system, providing the floor system is sufficiently rigid. If the floor, and its friction contact with the compression flange, are capable of resisting buckling in the required amount, the compression flange may be considered as laterally supported, and a reduction in working stress is not necessary.

Consider an example. What passive resistance per lineal foot is necessary to permit a 16″ @ 40# wide flange beam to carry a vertically applied uniform load causing an extreme fiber stress of 20000#/□″ on a simple span of 22 feet?

Computations prove that the 16″ @ 40# WF beam, if laterally supported, will carry a load of 39,000 lbs., uniformly distributed, on a 22-foot span. However, if laterally free, or unsupported, from the *ld/bt* equations of the 1946 A.I.S.C. specifications, the allowable fiber stress will be 10000#/□″, or a safe load of but 19,500 lbs. uniformly distributed will be the maximum permissible on a 22-foot span.

The stress resulting from unintentional eccentricity is therefore 20000 — 10000 = 10000#/□″, *if* the beam is actually laterally unsupported.

A passive lateral resistance, uniformly applied to the flange, must be capable of resisting a bending moment which would cause a stress of 10000#/□″ in the flange acting as a horizontal beam. The flange of the 16″ @ 40# WF beam is 7″ wide and approximately ½″ thick, with a lateral section modulus of

$$\frac{bd^2}{6} = \frac{0.5 \times 7^2}{6} = 4.1$$

At 10000#/□″ the bending moment is 41000″/#, but the bending moment is also $Wl/8$, and therefore

$$41000''/\# = \frac{Wl}{8} = \frac{W \times 22 \times 12}{8} = 33W \quad \text{and}$$

$$W = 41000 \div 33 = 1240\#$$

Thus, a total uniform lateral force of 1240# is necessary to reduce lateral buckling if the beam is to carry 39,000 lbs., uniformly distributed, on a 22-foot span. The lateral force of 1240# is 3.2% of the vertical load of 39,000#; if the floor is capable of providing resistance to this 1240# the flange will be laterally supported. It is evident that the friction between floor and beam is several times 3.2% of the vertical load.

Beams with concentrated loads, vertically applied, may be similarly analyzed.

TORSION IN ROLLED STEEL BEAMS

The Bethléhem Steel Company, in collaboration with Lehigh University, conducted very exhaustive studies on torsion. The derivation of the primary torsional factor, herein designated as "torsional constant K" is explained in the report of the Lehigh studies.

If the two flanges of an eccentrically loaded beam be restrained from warping longitudinally with reference to each other, secondary bending stresses are introduced. The secondary bending resistance of the flanges involves an expression which is designated herein "torsional bending constant a", wherein

$$a = \frac{g}{2}\sqrt{\frac{EI_2}{KE_s}} = 0.806\ g\sqrt{\frac{I_2}{K}} \text{ when Poisson's ratio is 0.30} \qquad (1)$$

In the formulae, two conditions of loading are assumed: simple spans only:

(1) Load uniformly distributed, entire span; constant eccentricity throughout.
(2) Single concentrated load at center of span, eccentrically applied.

No consideration is given to strengthening effect of end connections, tie rods, concrete floors, filler beams, walls, etc.

Moments:

	Uniform Load		*Concentrated Load*	
Max. Bending Moment, center of span:	$M_b = \frac{WL}{8}$	(2)	$M_b = \frac{WL}{4}$	(3)
Max. Torsional Moment:	$M_t = \frac{We}{2}$	(4)	$M_t = \frac{We}{2}$	(4)

Flange Stress, Center of Span:

	Uniform Load		*Concentrated Load*	
From Vertical Bending:	$f_b = \frac{M_b}{S_x}$	(5)	$f_b = \frac{M_b}{S_x}$	(5)
From Torsional Bending:	$f_t = M_tBQ_u$	(6)	$f_t = M_tBQ_c$	(7)

In which $B = \frac{ab}{gI_2}$; $Q_u = \tanh\frac{L}{2a} - \frac{2a}{L}\left\{1 - \frac{1}{\cosh\frac{L}{2a}}\right\}$; $Q_c = \tanh\frac{L}{2a}$

Combined Flange Stress at center: $F = f_b + f_t$ (8)

Total Angle of Twist 4:

	Uniform Load		*Concentrated Load*	
Angle of Twist, 4 (radians):	$\frac{1}{2} M_tCR_u$	(9)	M_tCR_c	(10)

In which $C = \frac{a}{KE_s}$; $R_u = \left[\left(\frac{L}{2a} - \tanh\frac{L}{2a}\right) - \frac{4a}{L}\tanh\frac{L}{2a}\left(\frac{L}{4a} - \tanh\frac{L}{4a}\right)\right]$;

$R_c = \frac{L}{2a} - \tanh\frac{L}{2a}$

Shears:

Maximum Shear for Vertical Load: $V = \frac{W}{2}$ (11)

Average Web Unit Shearing Stress, from Vertical Load: $S_v = \frac{V}{dw}$ (12)

Maximum Web Unit Shearing Stress, from Torsion: $S_t = M_tZ$ (13)

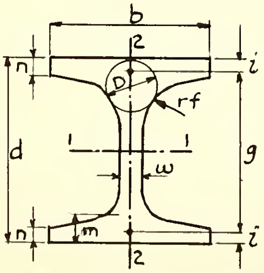
Maximum Web Unit Shearing Stress, combined Torsion and Vertical Load: $S_w = S_v + S_t$ (14)

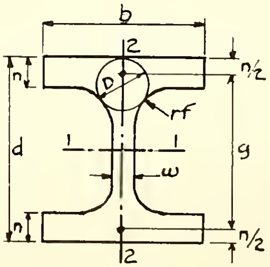
Maximum Flange Unit Shearing Stress, from Torsion: $S_f = M_tN$ (15)

(Stress at ends of beam, equations (12) to (15) inc.

In the above: $N = \frac{D + m}{2K}$ and $Z = \frac{w + 0.3\,r_f}{K}$

General:





It is believed that nomenclature as used is self-explanatory.

"K" values are not required for computing Bending or Torsional Moments or Flange Stresses. For Angle of Twist, use "K" from tables.

To convert radians to degrees, multiply by 57.30.

tanh = Hyperbolic Tangent.
cosh = Hyperbolic Cosine.

TORSION IN ROLLED STEEL BEAMS—CONT'D

As previously mentioned, the derivation of K values is given in detail in the original studies. The actual K values for various beams are given in the table below to facilitate analysis of a given section. For purposes of review, the equations for K are as follows:

Sloping Flange Sections:

$$K = \frac{b - w}{6}(m + n)(m^2 + n^2) + \frac{2}{3}wm^3 + \frac{1}{3}(d - 2m)w^3 + 2\alpha D^4 - 4V_s n^4 \qquad (16)$$

Parallel Flange Sections:

$$K = \frac{2}{3}bn^3 + \frac{1}{3}(d - 2n)w^3 + 2\alpha D^4 - 0.42016n^4 \qquad (17)$$

K VALUES FOR WIDE FLANGE BEAMS

NOMINAL SIZE	WEIGHT PER FT.	K
36x16½	300	68.8
	280	56.4
	260	44.8
	245	37.2
	230	30.9
36x12	194	23.7
	182	19.6
	170	16.0
	160	13.2
	150	10.8
33x15¾	240	39.3
	220	30.3
	200	22.8
33x11½	152	13.2
	141	10.4
	130	7.5
30x15	210	30.7
	190	22.9
	172	17.0
30x10½	132	10.4
	124	8.5
	116	6.9
	108	5.4
27x14	177	21.6
	160	16.6
	145	12.2
27x10	114	7.9
	102	5.5
	94	4.0
24x14	160	17.8
	145	13.3
	130	9.5
24x12	120	8.8
	110	6.9
	100	5.2
24x9	94	5.6
	84	4.0
	76	3.0

NOMINAL SIZE	WEIGHT PER FT.	K
21x13	142	15.3
	127	12.0
	112	7.6
21x9	96	6.9
	82	4.3
21x8¼	73	3.2
	68	2.6
	62	1.9
18x11¾	114	9.9
	105	7.8
	96	6.0
18x8¾	85	5.8
	77	4.4
	70	3.3
	64	2.6
18x7½	60	2.4
	55	1.8
	50	1.3
16x11½	96	6.8
	88	5.2
16x8½	78	5.1
	71	3.9
	64	2.9
	58	2.1
16x7	50	1.6
	45	1.2
	40	0.9
	36	0.6
14x16	426	338.6
	398	278.7
	370	227.0
	342	181.5
	314	142.6
	287	110.0
	264	86.9
	246	70.9
	237	63.6
	228	57.1

NOMINAL SIZE	WEIGHT PER FT.	K
14x16 CONT'D	219	50.7
	211	45.5
	202	40.2
	193	35.2
	184	30.8
	176	26.9
	167	23.1
	158	19.8
	150	17.0
	142	14.4
	320	134.1
14x14½	136	16.7
	127	13.9
	119	11.7
	111	9.6
	103	7.8
	95	6.3
	87	5.0
14x12	84	4.5
	78	3.6
14x10	74	3.9
	68	3.1
	61	2.2
14x8	53	2.0
	48	1.5
	43	1.1
14x6¾	38	0.9
	34	0.6
	30	0.4
12x12	190	50.0
	161	31.2
	133	18.0
	120	13.1
	106	9.2
	99	7.5
	92	6.1
	85	4.9
	79	3.9

NOMINAL SIZE	WEIGHT PER FT.	K
12x12 CONT'D	72	3.0
	65	2.2
12x10	58	2.1
	53	1.6
12x8	50	1.8
	45	1.3
	40	1.0
12x6½	36	0.9
	31	0.5
	27	0.4
10x10	112	15.3
	100	11.1
	89	7.9
	77	5.2
	72	4.2
	66	3.3
	60	2.5
	54	1.9
	49	1.4
10x8	45	1.5
	39	1.0
	33	0.6
10x5¾	29	0.6
	25	0.4
	21	0.2
8x8	67	5.1
	58	3.4
	48	2.0
	40	1.1
	35	0.8
	31	0.5
8x6½	28	0.5
	24	0.4
8x5¼	20	0.3
	17	0.2

K VALUES FOR STANDARD BEAMS

NOMINAL SIZE	WEIGHT PER FT.	K
24x8	120.0	13.15
	105.9	10.62
24x7	100.0	7.70
	90.0	6.14
	79.9	5.01
20x7	95.0	8.55
	85.0	6.76
20x6¼	75.0	4.66
	65.4	3.57

NOMINAL SIZE	WEIGHT PER FT.	K
18x6	70.0	4.19
	54.7	2.41
15x5½	50.0	2.15
	42.9	1.57
12x5¼	50.0	2.85
	40.8	1.78
12x5	35.0	1.10
	31.8	0.92

NOMINAL SIZE	WEIGHT PER FT.	K
10x4¾	35.0	1.31
	25.4	0.62
8x4	23.0	0.56
	18.4	0.34
7x3¾	20.0	0.46
	15.3	0.25
6x3½	17.25	0.38
	12.5	0.17

NOMINAL SIZE	WEIGHT PER FT.	K
5x3	14.75	0.33
	10.0	0.12
4x2⅝	9.5	0.12
	7.7	0 07
3x2⅜	7.5	0.09
	5.7	0.05

UNIFORMLY LOADED STEEL BEAMS

REQUIRED SECTION MODULII

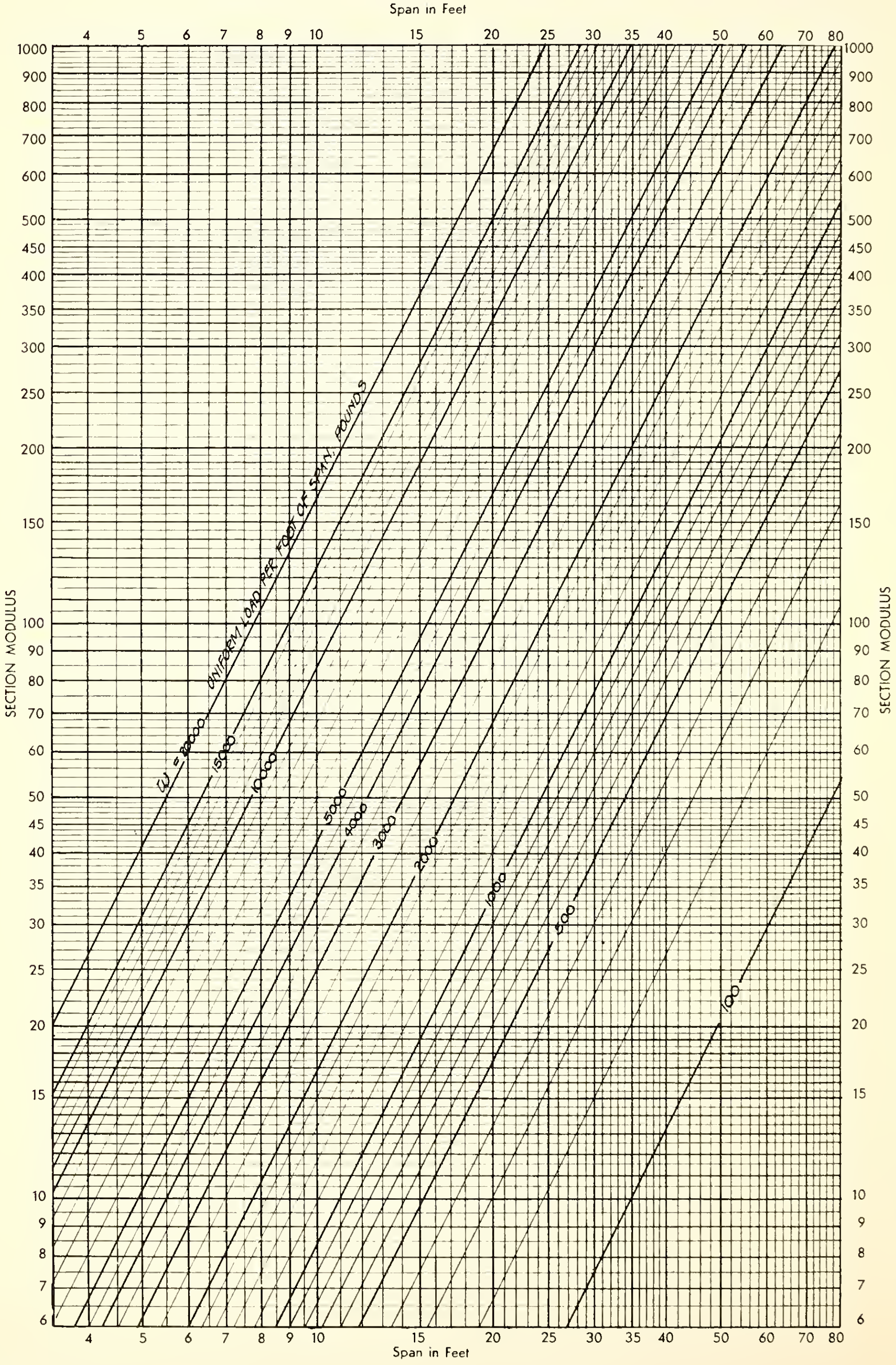
Graph 3

$f = 18{,}000$ lbs. sq. in.

$M = \frac{wL^2}{8}$

Freely Supported Ends

Beams Supported Laterally



UNIFORMLY LOADED STEEL BEAMS

REQUIRED SECTION MODULII

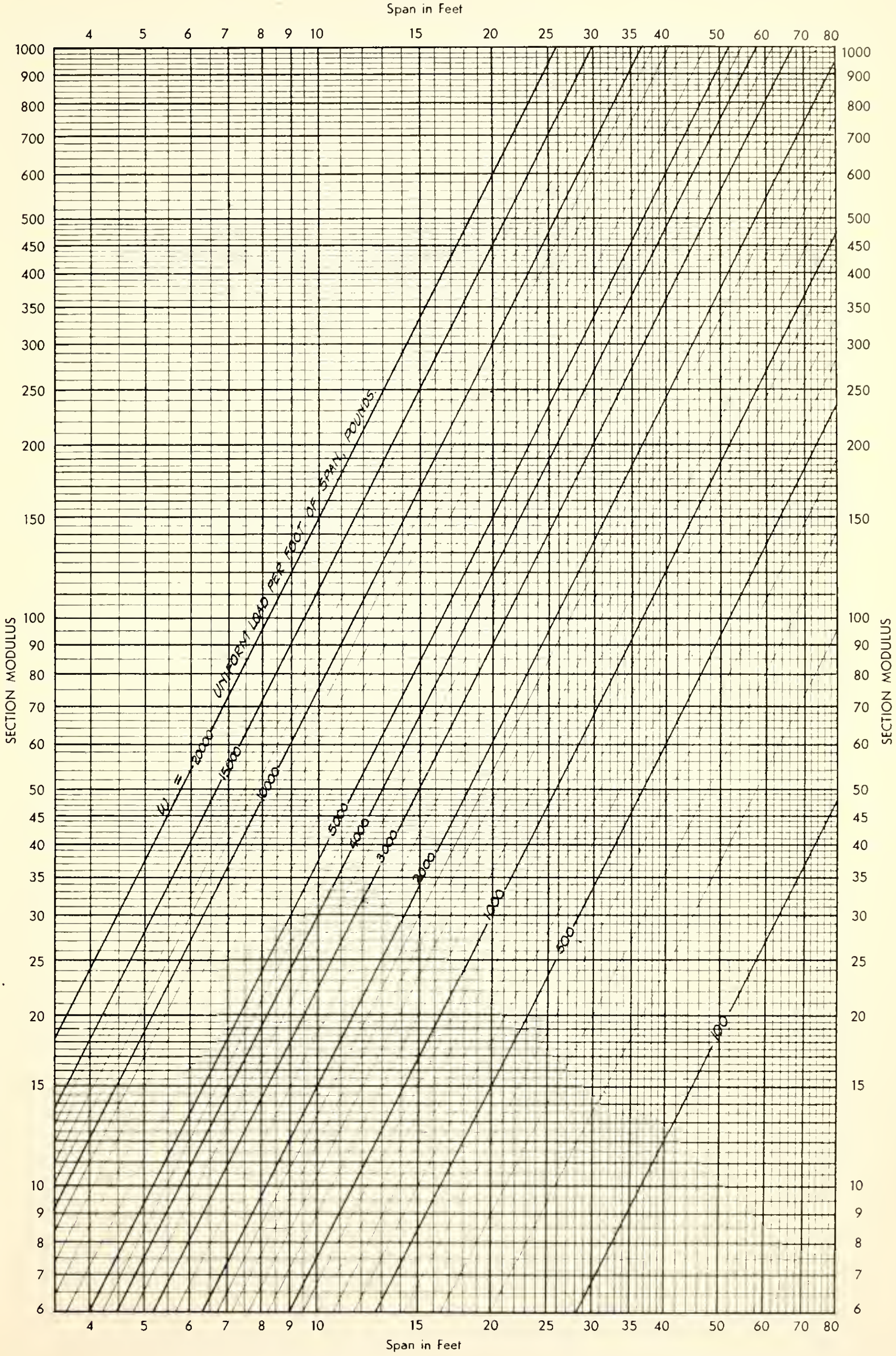
Graph 3A

$f = 20{,}000$ lbs sq in.

$M = \frac{wL^2}{8}$

Freely Supported Ends

Beams Supported Laterally



REQUIRED SECTION MODULUS OF STEEL BEAMS

FOR VARIOUS UNIFORM LOADS, PER LINEAL FOOT
18000 LB. FIBER STRESS

$$M = \frac{wl^2}{8}$$

COMPUTE TOTAL LOAD PER LIN. FT. OF BEAM: OPPOSITE THIS LOAD, UNDER PROPER SPAN, FIND REQ'D SECTION MODULUS

TOTAL LOAD LB. LIN. FT.	SPAN IN FEET																						
	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	24	26	28	30	32	34	36	38	40
250	1	2	2	3	3	4	4	5	5	6	7	8	8	9	10	12	14	16	19	21	24	27	30	33
300	2	2	3	3	4	4	5	6	6	7	8	9	10	11	12	14	17	20	23	26	29	32	36	40
350	2	2	3	4	4	5	6	7	7	8	9	11	12	13	14	17	20	23	26	30	34	38	42	47
400	2	3	3	4	5	6	7	8	9	10	11	12	13	15	16	19	23	26	30	34	39	43	48	53
450	2	3	4	5	5	6	7	8	10	11	12	14	15	17	18	22	25	29	34	38	43	49	54	60
500	3	3	4	5	6	7	8	9	11	12	14	15	17	18	20	24	28	33	38	43	48	54	60	67
550	3	4	5	6	7	8	9	10	12	13	15	17	18	20	22	26	31	36	41	47	53	59	66	73
600	3	4	5	6	7	8	10	11	13	14	16	18	20	22	24	29	34	39	45	51	58	65	72	80
650	3	4	5	7	8	9	11	12	14	16	18	20	22	24	26	31	37	42	49	55	63	70	78	87
700	4	5	6	7	8	10	11	13	15	17	19	21	23	26	28	34	39	46	53	60	67	76	84	93
750	4	5	6	8	9	11	12	14	16	18	20	23	25	28	30	36	42	49	56	64	72	81	90	100
800	4	5	7	8	10	11	13	15	17	19	22	24	27	29	32	38	45	52	60	68	77	86	96	107
850	5	6	7	9	10	12	14	16	18	21	23	26	28	31	34	41	48	56	64	73	82	92	102	113
900	5	6	8	9	11	13	15	17	19	22	24	27	30	33	36	43	51	59	68	77	87	97	108	120
950	5	6	8	10	11	13	16	18	20	23	26	29	32	35	38	46	54	62	71	81	92	103	114	127
1000	5	7	8	10	12	14	16	19	21	24	27	30	33	37	40	48	56	65	75	85	96	108	120	133
1050	6	7	9	11	13	15	17	20	22	25	28	32	35	39	42	50	59	69	79	90	101	113	126	140
1100	6	7	9	11	13	16	18	21	23	27	30	33	37	40	44	53	62	72	83	94	106	119	132	147
1150	6	8	10	12	14	16	19	22	25	28	31	35	38	42	46	55	65	75	86	98	111	124	138	153
1200	6	8	10	12	14	17	20	22	26	29	32	36	40	44	48	58	68	78	90	102	116	130	144	160
1250	7	8	10	13	15	18	20	23	27	30	34	38	42	46	50	60	70	82	94	107	120	135	150	167
1300	7	9	11	13	16	18	21	24	28	31	35	39	43	48	53	62	73	85	98	111	125	140	136	173
1350	7	9	11	14	16	19	22	25	29	33	37	41	45	50	55	65	76	88	101	115	130	146	162	180
1400	7	9	12	14	17	20	23	26	30	34	38	42	47	51	57	67	79	92	105	119	135	151	169	187
1450	8	10	12	15	17	20	24	27	31	35	39	44	48	53	59	70	82	95	109	124	140	157	175	193
1500	8	10	13	15	18	21	25	28	32	36	41	45	50	55	61	72	84	98	113	128	145	162	181	200
1550	8	10	13	16	19	22	26	29	33	37	42	47	52	57	63	74	87	101	116	132	149	167	187	207
1600	9	11	13	16	19	23	26	30	34	39	43	48	53	59	65	77	90	105	120	136	154	173	193	213
1650	9	11	14	17	20	23	27	31	35	40	45	50	55	61	67	79	93	108	124	141	159	178	199	220
1700	9	11	14	17	20	24	28	32	36	41	46	51	57	63	69	82	96	111	128	145	164	184	205	227
1750	9	12	15	18	21	25	29	33	37	42	47	53	58	64	71	84	99	114	131	149	169	189	211	233
1800	10	12	15	18	22	25	29	34	38	43	49	54	60	66	73	86	101	118	135	154	173	194	217	240
1850	10	13	15	19	22	26	30	35	39	45	50	56	62	68	75	89	104	121	139	158	178	200	223	247
1900	10	13	16	19	23	27	31	36	40	46	51	57	63	70	77	91	107	124	143	162	183	205	229	253
1950	10	13	16	20	23	28	32	37	42	47	53	59	65	72	79	94	110	127	146	166	188	211	235	260
2000	11	14	17	20	24	28	33	38	43	48	54	60	67	74	81	96	113	131	150	171	193	216	241	267
2100	11	14	18	21	25	30	34	39	45	51	57	63	70	77	85	101	118	137	158	179	202	227	253	280
2200	12	15	18	22	26	31	36	41	47	53	60	66	73	81	89	105	124	144	165	188	212	238	265	293
2300	12	16	19	23	28	32	38	43	49	55	62	69	77	85	93	110	130	150	173	196	222	248	277	307
2400	13	16	20	24	29	34	39	45	51	58	65	72	80	88	97	115	135	157	180	205	231	259	289	320
2500	13	17	21	25	30	35	41	47	53	60	68	75	83	92	101	120	141	163	188	213	241	270	301	333
2600	14	18	22	26	31	37	43	49	55	63	70	78	87	96	105	125	146	170	195	222	251	281	313	347
2700	14	18	23	27	32	38	44	51	58	65	73	81	90	99	109	130	152	176	203	230	260	292	325	360
2800	15	19	23	28	34	39	46	53	60	68	76	84	93	103	113	134	158	183	210	239	270	302	337	373
2900	16	20	24	29	35	41	47	54	62	70	78	87	97	107	117	139	163	190	218	247	280	313	349	387
3000	16	20	25	30	36	42	49	56	64	72	81	90	100	110	121	144	169	196	225	256	289	324	361	400
3200	17	22	27	32	38	45	52	60	68	77	87	96	107	118	129	154	180	209	240	273	308	346	385	427
3400	18	23	28	34	41	48	56	64	73	82	92	102	113	125	137	163	192	222	255	290	328	367	409	453
3600	19	24	30	36	43	51	59	68	77	87	97	108	120	133	145	173	203	235	270	307	347	388	433	480
3800	20	26	32	38	46	54	62	71	81	92	103	114	127	140	153	183	214	248	285	324	366	410	457	507
4000	21	27	33	40	48	56	65	75	85	96	108	120	133	147	161	192	225	261	300	341	385	432	482	533
4200	22	28	35	42	50	59	69	79	90	101	113	126	140	154	170	202	237	274	315	358	405	453	505	560
4400	24	30	37	44	53	62	72	83	94	106	119	132	147	162	178	211	248	287	330	375	424	475	530	587
4600	25	31	38	46	55	65	75	86	98	111	124	138	153	169	186	221	259	300	345	392	443	497	554	613
4800	26	32	40	48	58	68	79	90	102	116	130	144	160	176	194	230	270	314	360	409	463	518	578	640
5000	27	34	42	50	60	71	82	94	107	121	135	150	167	184	202	240	281	326	375	426	482	540	602	667
5200	28	35	43	52	62	73	85	98	111	125	140	156	173	191	210	250	293	340	390	443	501	561	626	693
5400	29	36	45	54	65	76	88	101	115	130	146	162	180	199	218	259	304	353	405	460	520	583	650	720
5600	30	38	47	56	67	79	92	105	119	135	151	168	187	206	226	269	315	366	420	477	540	604	674	747
5800	31	39	48	58	70	82	95	109	124	140	157	174	193	214	234	278	327	379	435	494	559	626	698	773

REQUIRED SECTION MODULUS OF STEEL BEAMS

FOR VARIOUS UNIFORM LOADS PER LINEAL FOOT

$M = \frac{Wl^2}{8}$

20,000 LB. FIBER STRESS

Compute Total Load per Lineal Foot of Beam; opposite this load, under proper span, find Req'd S

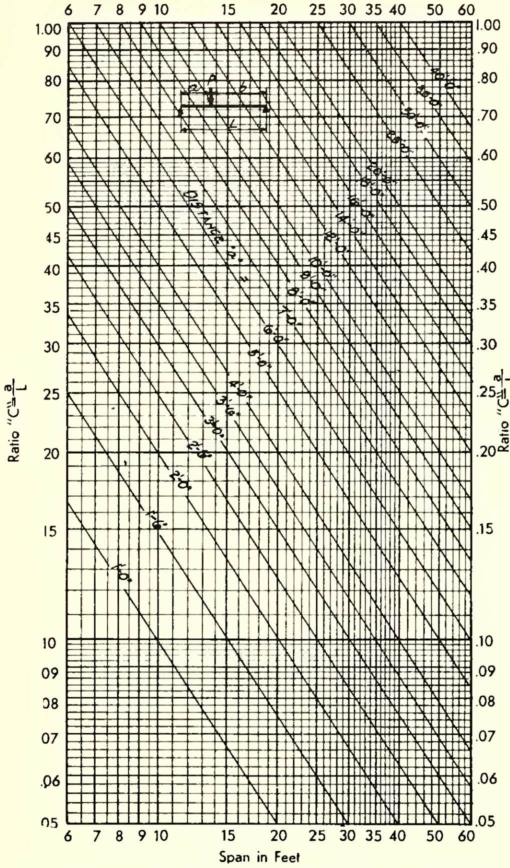
LOAD PER LIN. FT.	SPAN IN FEET																							
	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	24	26	28	30	32	34	36	38	40
250	1	2	2	2	3	3	4	4	5	5	6	7	8	8	9	11	13	15	17	19	22	24	27	30
300	1	2	2	3	3	4	4	5	6	7	7	8	9	10	11	13	15	18	20	23	26	29	33	36
350	2	2	3	3	4	4	5	6	7	8	9	9	11	12	13	15	18	21	24	27	30	34	38	42
400	2	2	3	4	4	5	6	7	8	9	10	11	12	13	15	17	20	24	27	31	35	39	43	48
450	2	3	3	4	5	6	7	8	9	10	11	12	14	15	16	19	23	26	30	35	39	44	49	54
500	2	3	4	5	5	6	7	8	10	11	12	14	15	17	18	22	25	29	34	38	43	49	54	60
550	3	3	4	5	6	7	8	9	11	12	13	15	17	18	20	24	28	32	37	42	48	53	60	66
600	3	4	5	5	6	8	9	10	12	13	15	16	18	20	22	26	30	35	41	46	52	58	65	72
650	3	4	5	6	7	8	10	11	12	14	16	18	20	22	24	28	33	38	44	50	56	63	70	78
700	3	4	5	6	8	9	10	12	13	15	17	19	21	23	25	30	35	41	47	54	61	68	76	84
750	4	5	6	7	8	10	11	13	14	16	18	20	23	25	27	32	38	44	51	58	65	73	81	90
800	4	5	6	7	9	10	12	14	15	17	19	22	24	26	29	35	40	47	54	62	69	78	87	96
850	4	5	6	8	9	11	12	14	16	18	21	23	26	28	31	37	43	50	57	65	74	83	92	102
900	4	5	7	8	10	11	13	15	17	20	22	24	27	30	33	39	45	53	61	69	78	88	98	108
950	5	6	7	9	10	12	14	16	18	21	23	26	29	31	35	41	48	56	64	73	82	92	103	114
1000	5	6	8	9	11	13	15	17	19	22	24	27	30	33	36	43	51	59	67	77	87	97	108	120
1050	5	6	8	10	11	13	15	18	20	23	26	28	32	35	38	45	53	62	71	81	91	102	114	126
1100	5	7	8	10	12	14	16	19	21	24	27	30	33	36	40	48	56	65	74	85	95	107	119	132
1150	6	7	9	10	12	15	17	19	22	25	28	31	35	38	42	50	58	68	78	88	100	112	125	138
1200	6	7	9	11	13	15	18	20	23	26	29	32	36	40	44	52	61	71	81	92	104	117	130	144
1250	6	8	9	11	14	16	18	21	24	27	30	34	38	41	45	54	63	73	84	96	108	121	136	150
1300	6	8	10	12	14	17	19	22	25	28	32	35	39	43	47	56	66	76	88	100	113	126	141	156
1350	6	8	10	12	15	17	20	23	26	29	33	37	41	45	49	58	68	79	91	104	117	131	146	162
1400	7	9	11	13	15	18	21	24	27	30	34	38	42	46	51	61	71	82	94	107	121	136	152	168
1450	7	9	11	13	16	18	21	25	28	31	35	39	44	48	53	63	73	85	98	111	126	141	157	174
1500	7	9	11	14	16	19	22	25	29	33	36	41	45	50	54	65	76	88	101	115	130	146	163	180
1550	7	9	12	14	17	20	23	26	30	34	38	42	47	51	56	67	78	91	105	119	134	150	168	186
1600	8	10	12	15	17	20	24	27	31	35	39	43	48	53	58	69	81	94	108	123	139	155	174	192
1650	8	10	12	15	18	21	24	28	32	36	40	45	50	55	60	71	83	97	111	127	143	160	179	198
1700	8	10	13	15	18	22	25	29	33	37	41	46	51	56	62	74	86	100	115	131	147	165	184	204
1750	8	11	13	16	19	22	26	30	34	38	43	47	53	58	63	76	88	103	118	134	152	170	190	210
1800	9	11	14	16	19	23	26	30	35	39	44	49	54	60	65	78	91	106	121	138	156	175	195	216
1850	9	11	14	17	20	24	27	31	35	40	45	50	56	61	67	80	93	109	125	142	160	179	200	222
1900	9	12	14	17	21	24	28	32	36	41	46	51	57	63	69	82	96	112	128	146	165	184	206	228
1950	9	12	15	18	21	25	29	33	37	42	47	53	59	65	71	84	99	115	131	150	169	189	211	234
2000	10	12	15	18	22	25	29	34	38	43	48	54	60	66	72	87	101	118	135	154	173	194	217	240
2100	10	13	16	19	23	27	31	35	40	46	51	57	63	70	76	91	106	123	142	161	182	204	228	252
2200	11	13	16	20	24	28	32	37	42	48	53	60	66	73	80	95	111	129	148	169	191	214	238	264
2300	11	14	17	21	25	29	34	39	44	50	56	62	69	76	83	99	116	135	155	177	199	223	249	276
2400	12	14	18	22	26	30	35	41	46	52	58	65	72	79	87	104	121	141	162	185	208	233	260	288
2500	12	15	19	23	27	32	37	42	48	54	61	68	75	83	91	108	126	147	169	192	216	242	271	300
2600	12	16	20	24	28	33	38	44	50	56	63	70	78	86	94	112	131	153	175	200	225	252	282	312
2700	13	16	20	25	29	34	40	46	52	58	66	73	81	89	98	117	136	159	182	208	234	262	293	324
2800	13	17	21	25	30	36	41	47	54	61	68	76	84	93	102	121	141	165	189	215	242	272	303	336
2900	14	18	22	26	31	37	43	49	56	63	70	78	87	96	105	125	147	170	195	223	251	282	314	348
3000	14	18	23	27	32	38	44	51	58	65	73	81	90	99	109	130	152	176	202	230	260	291	325	360
3200	15	19	24	29	35	41	47	54	61	69	78	87	96	106	116	138	162	188	216	246	277	310	347	384
3400	16	21	26	31	37	43	50	57	65	74	83	92	102	112	123	147	172	200	229	261	294	330	368	408
3600	17	22	27	33	39	46	53	61	69	78	88	98	108	119	131	156	182	211	243	277	312	350	390	432
3800	18	23	29	34	41	48	56	64	73	82	92	103	114	126	138	164	192	223	256	292	329	369	412	456
4000	19	24	30	36	43	51	59	68	77	87	97	108	120	132	145	173	202	235	270	308	346	388	433	480
4200	20	25	32	38	45	53	62	71	81	91	102	113	126	139	152	182	212	247	283	323	364	408	455	504
4400	21	27	33	40	48	56	65	74	84	95	107	119	132	146	160	190	223	258	297	338	381	427	477	528
4600	22	28	35	42	50	58	68	78	88	100	112	124	138	152	167	199	233	270	310	354	398	447	498	552
4800	23	29	36	44	52	61	71	81	92	104	117	130	144	159	174	208	243	282	324	369	416	465	520	576
5000	24	30	38	45	54	63	73	84	96	108	121	135	150	165	181	216	253	294	337	384	433	485	541	600
5200	25	31	39	47	56	66	76	88	100	113	126	141	156	172	188	225	263	305	351	400	450	505	563	624
5400	26	33	41	49	58	68	79	91	104	117	131	146	162	179	196	233	273	317	364	415	468	524	585	648
5600	27	34	42	51	61	71	82	95	107	121	136	151	168	185	203	242	283	329	378	430	485	543	607	672
5800	28	35	44	53	63	74	85	98	111	126	141	157	174	192	210	251	294	341	391	446	502	563	629	696

STEEL BEAMS WITH CONCENTRATED LOADS

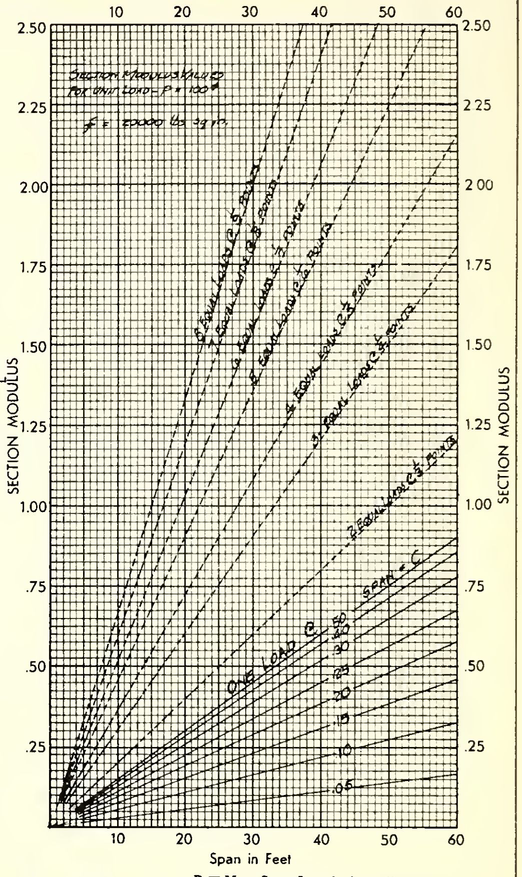
S Section Modulus

Freely Supported Ends

Graph 1



Graph 2



V = Max. allowable web shear, kips

WIDE FLANGE BEAMS

D = Max. Span Length, laterally supported, for permissible deflection, U. L.

Sec.	WT. PER FOOT	S	Limits V.	Limits D.
6" LB	8.5	5.1	13	9
	12	7.2	18	9
	16	10.1	21	10
8" LB	10	7.8	17	12
	13	9.9	24	13
	15	11.8	26	13
10" LB	11.5	10.5	23	16
	15	13.8	30	16
	17	16.2	32	16
	19	18.8	33	16
12" LB	14	14.8	31	19
	16.5	17.5	36	19
	19	21.4	38	19
	22	25.3	42	19
8" WF	17	14.1	24	12
	20	17.0	26	12
	24	20.8	25	12
	28	24.3	30	12
	31	27.4	30	12
	35	31.1	33	13
	40	35.5	39	13
	48	43.2	45	13

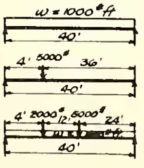
Sec.	WT. PER FOOT	S	Limits V.	Limits D.
10" WF	21	21.5	31	15
	25	26.4	33	16
	29	30.8	38	16
	33	35.0	37	15
	39	42.2	41	15
	45	49.1	46	16
	49	54.6	44	16
	54	60.4	48	16
	60	67.1	55	16
	66	73.7	62	16
12" WF	27	34.1	37	19
	31	39.4	41	19
	36	45.9	49	19
	40	51.9	46	19
	45	58.2	53	19
	50	64.7	59	19
	53	70.7	54	19
	58	78.1	57	19
	65	88.0	61	19
	72	97.5	69	19
	79	107	76	19
	85	116	80	19

Sec.	WT. PER FOOT	S	Limits V.	Limits D.
14" WF	30	41.8	49	22
	34	48.5	52	22
	38	54.6	58	22
	43	62.7	55	22
	48	70.2	61	22
	53	77.8	67	22
	61	92.2	68	22
	68	103	76	22
	74	112	83	22
	78	121	78	22
	84	131	83	22
	87	138	76	22
	95	151	85	22
	103	164	92	23
	111	176	101	23
	119	189	107	23
	127	202	116	23
	136	216	126	23
	142	227	130	23
	150	240	134	23
	158	253	142	23
	167	267	153	23

Sec.	WT. PER FOOT	S	Limits V.	Limits D.
16" WF	36	56.3	62	26
	40	64.4	64	26
	45	72.4	73	26
	50	80.7	80	26
	58	94.1	84	26
	64	104	92	26
	71	116	102	26
	78	128	112	26
	88	151	106	26
	96	166	114	26
18" WF	50	89.0	84	29
	55	98.2	92	29
	60	108	99	29
	64	117	94	28
	70	128	103	29
	77	142	112	29
	85	156	125	29
	96	184	121	29
	105	202	132	29
	114	220	143	29

Sec.	WT. PER FOOT	S	Limits V.	Limits D.
21" WF	62	126	109	33
	68	140	118	34
	73	151	126	34
	82	168	135	33
	96	198	158	34
	112	250	144	33
	127	284	163	34
	142	317	184	34
24" WF	76	175	137	38
	84	196	147	38
	94	221	163	39
	100	249	146	38
	110	274	160	38
	120	299	176	39
	130	331	178	39
	145	373	194	39
	160	414	211	39
27" WF	94	243	172	43
	102	266	182	43
	114	299	202	44
	145	403	210	43
	160	445	232	44
	177	493	257	44

Sec.	WT. PER FOOT	S	Limits V.	Limits D.
30" WF	108	299	212	48
	116	328	220	48
	124	355	229	48
	132	380	242	48
	172	528	254	48
	190	586	278	48
	210	650	306	49
33" WF	130	405	249	53
	141	447	262	53
	152	486	277	54
	200	670	307	53
	220	741	335	53
	240	811	362	54
36" WF	150	503	291	57
	160	541	306	58
	170	579	320	58
	182	621	342	58
	194	664	365	58
	230	836	357	57
	245	893	376	58
	260	951	398	58
	280	1031	420	58
	300	1105	451	59



UNIFORM LOAD: From Graph 3A, at intersection of 1000# load line and 40′ span, read $S = 120$.

SINGLE CONC. LOAD: With "a" = 4′-0″, $C = .10$ from Graph 1. With this as a basis from Graph 2 with $C = .10$ and span of 40′-0″, intersection gives $S = .216$ for a unit load of 100 lbs. Therefore, for a load of 5000 lbs., $S = (5000 \div 100) \times .216 = 10.8$. For the Left Reaction (R_L) transpose, reading $a = 36'$ instead of 4. Thereupon $C = .90$, and $R_L = .90\,P = .90 \times 5000 = 4500$#.

MULTIPLE CONC. LOADS: With "a" = 4′, $C' = .10$; with "a" = 16′, $C'' = .40$; with "a" = 20′, $C''' = .50$ for U. L. To find reaction R_L, transpose "b" for "a" and: For P_1, $2000 \times .90 = 1800$; for P_2, $5000 \times .60 = 3000$; for W_1, $(500 \times 40) \times .50 = 10000$. Therefore $\Sigma = 1800 + 3000 + 10000 = 14800 = R_L$.

Since R_L equals or exceeds the total load at P_2, point of max. moment, is at $P_2 = R_L \times 16 = 236800$ ft. lbs. From this deduct $(12 \times 2000) + (16 \times 500 \times 8) = 88000$, leaving 148800 ft. lbs. as max. moment. Mutiplying by 12, moment in inch pounds = 1,785,600. With fiber stress of 20000#/□″, $S = 1{,}785{,}600 \div 20000 = 89\,28$.

BEAM BEARING PLATES

LOOSE PLATES:

A solid rectangular beam section, a rolled steel beam with flanges of sufficient thickness to resist bending as a cantilever, or a steel beam with stiffeners ground to fit the flanges, would produce uniform pressure under the flange, on top of the bearing plate; the plate would tend to bend at the toe of the beam flange. The moment in the plate at this point would be

$M = \frac{pB\,(B - b)}{8} = \frac{ft^2}{6}$ per lineal inch, and the required thickness would be

$$t = \sqrt{\frac{3pB\,(B - b)}{4f}}$$

Actually, the beam flange would tend to deflect, unless stiffeners are used, no matter how small the load, and would thus permit bending in the bearing plate under the flange. However, if the flange is thick enough to withstand the calculated bending stresses, this deflection in plate may be disregarded.

With a given thickness, "*t*", the maximum allowable moment in the flange at the critical section, which may be considered as at the root of the fillet, would be

$M = \frac{ft^2}{6}$, and the maximum allowable unit pressure to produce this moment

would be $p = \frac{M}{0.5e^2}$

The nomenclature used is:

a = Length, loaded portion, in feet.
b = Width of beam flange, inches.
B = Length bearing plate, right angle with beam, in.
d = Depth of beam, inches.
e = Moment arm, inches.
f_b = Unit web buckling.
f_v = Unit web shear.
L = Length grillage beams, feet.
M = Moment, inch lbs.
n = Number beams in grillage.
p = Unit pressure.
t = Thickness of bearing plate.
W = Width of bearing plate, parallel with beam
f = Unit stress in steel.

Consider a 24″ @ 100# C. B. section with end reaction of 60,000#, with 12″ wall thickness available for bearing. Flange 12″ wide and 0.767″ thick. The distance from center of web to root of fillet is 1.035″, and the cantilever projection of the flange beyond this point, "*e*", is therefore (12 ÷ 2) — 1.035 = 4.965″. Considering the beam as resting directly on wall, with no bearing plate, the unit pressure under the flange is then 60,000 ÷ (12 × 12) = 416#/□″. Actually, the maximum moment that the flange will resist is

$M = \frac{18{,}000 \times 0.767^2}{6} = 1{,}770$ in. lbs. per lin. inch, and the maximum allowable pressure is $p = \frac{1{,}770}{0.5 \times 4.965^2} = 144$ lbs. sq. in.

The actual moment at root of fillet, with 416# unit pressure, is

$M = \frac{pe^2}{2} = \frac{416 \times 4.965^2}{2} = 5{,}120$ in. lbs., and the required flange thickness is

$t = \sqrt{\frac{6M}{f}} = \sqrt{\frac{6 \times 5{,}120}{18{,}000}} = 1.31''$, instead of 0.767″ as provided.

With a loose bearing plate, the total resistance is the sum of the resistances of flange and plate considered separately, as the two will not act as a unit.

Consider conditions as above, with the exception that the allowable pressure on masonry is 250 lbs. sq. in. instead of 416#. The length bearing plate required will then be 60,000 ÷ (12 × 250) = 20″.

The total moment, with length "*e*" of 8.965″ (distance from fillet root to edge of plate) is $M = \frac{pe^2}{2} = \frac{250 \times 8.965^2}{2} = 10{,}050$ in. lbs.

Since the flange can resist but 1,770 in. lbs., the plate must provide for remainder, or 10,050 — 1,770 = 8,280. The required plate thickness is therefore

$t = \sqrt{\frac{6M}{f}} = \sqrt{\frac{6 \times 8{,}280}{18{,}000}} = 1.66''$.

Actually, the relatively thin flange and heavy plate will not have the same deflection curve under load, and theoretically, the same fiber stress should not be used in designing both plate and flange. From a practical standpoint, however, it is permissible to use the same stress. If the resistance of the beam flange were entirely disregarded, the beam load being considered as direct bearing on the plate over a width equal to web thickness plus twice the fillet distance, the total moment of 10,050 in. lbs. would require $t = \sqrt{\frac{6 \times 10{,}050}{18{,}000}} = 1.83''$, or but slightly more than when flange is considered.

When the flange is thick enough to resist bending caused by unit pressure, the maximum moment is $M = \frac{pB\,(B-b)}{8} = \frac{ft^2}{6}$ per lin. inch, as before, and $t = \sqrt{\frac{3pB\,(B-b)}{4f}}$

In order to use this formula, which requires less thickness of plate, it is necessary to investigate the flange under the pressure considered. The end reaction of beam, divided by flange width times length of bearing, gives unit pressure under flange. Assume the 24" @ 100# C. B. has a reaction of 20,000#. The unit pressure under flange is 20,000 ÷ (12 × 12) = 139#. With dimensions as before, the moment resisted by flange is

$M = \frac{18{,}000 \times 0.767^2}{6} = 1{,}770$ in. lbs. per lin. inch, and the permissible pressure is

$p = \frac{1{,}770}{0.5 \times 4.965^2} = 144\#$. This is satisfactory, as actual pressure is 139# sq. in.

RIVETED PLATES:

If the bearing plate is riveted or welded to the beam, the theory is changed. The plate and flange may be considered as acting together, and their combined thickness as available for resisting bending.

Consider the same 24" @ 100# C. B., reaction of 60,000#, allowable "p" of 250#. Maximum moment is $M = \frac{p(B-b)^2}{8} = \frac{ft^2}{6}$, and thickness, "$t$" = ½ $(B-b)\sqrt{\frac{3p}{f}}$

In the example, computing "t" for plate thickness at toe of flange

$$t = \tfrac{1}{2}\,(20-12)\quad \frac{3 \times 250}{18{,}000} = 0.82''$$

With thin flanged beams the bending at root of fillet must be investigated. At this point $M = \frac{pe^2}{2} = \frac{250 \times 8.965^2}{2} = 10{,}050$ in. lbs., and

$$t = \sqrt{\frac{6 \times 10{,}050}{18{,}000}} = 1.83'', \text{ total thickness flange and plate.}$$

The required plate thickness at fillet = 1.83 — 0.767 = 1.063", and would govern.

GRILLAGE, No Plate Under Beam:

Assume same beam as before, 60,000# reaction, but unit pressure of 100# sq. in. The required length is 60,000 ÷ (12 × 100) = 50". This is extreme for plate, so grillage will be used. The point of maximum moment will be taken as at fillet of beam, making "e", the cantilever arm, 23.965". The moment is

$M = \frac{pe^2}{2} = \frac{100 \times 23.965^2}{2} = 28{,}700$ in. lbs. per lin. inch, or

$M = 12 \times 28{,}700 = 344{,}000$ in. lbs. total for 12" width. Using 2 beams,

$\frac{I}{c} = \frac{344{,}000}{2 \times 18{,}000} = 9.6$. Try 2 — 7" @ 15.3# I ($\frac{I}{c} = 10.4$ each), web 0.25".

Buckling: $f_b = \frac{R}{n(12a + d/2)t} = \frac{60{,}000}{2(12 + 3.5).25} = 7{,}750\#$. (Allowable 14,271.)

Shear: $f_v = \frac{R}{L} \times \frac{L-a}{2} \times \frac{1}{ndt} = \frac{60{,}000}{50} \times \frac{50-12}{2} \times \frac{1}{2 \times 7 \times .25} = 13{,}000.$

(Allowable 12,000)

The grillage beams are a little weak in shear, and should be redesigned for more web area.

GENERAL.

Grillages may also be designed using loose or riveted plates under the girder, but their design presents no unusual difficulties. Any moment provided by the bearing plate may quite properly be deducted from the total moment, the grillage beams designed for the remainder.

Grillage beams should be connected by means of separators and, unless the flange area bearing on masonry walls is sufficient to keep the allowable pressure within limits, should be encased in concrete to give uniform bearing.

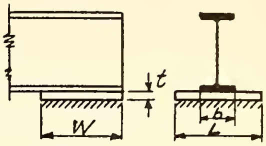
The tables on page 128 are based on assumption that flange will resist bending.

P = Unit Pressure, lbs. per sq. in.
W = Width of plate, parallel to beam, inches.
L = Length of plate, perpendicular to beam, in.
b = Width of beam flange, inches.
t = Thickness of plate, inches.

BEARING PLATES

FOR STEEL BEAMS

fₛ = 18,000



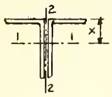
ALLOWABLE LOAD

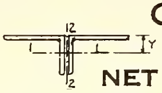
UNIT PRESSURE P	W	Allowable Load in Kips, For Length "L" as Given																			W	UNIT PRESSURE P
		12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30		
100	8	10	10	11	12	13	14	14	15	16	17	18	18	19	20	21	22	22	23	24	8	100
	12	14	16	17	18	19	20	22	23	24	25	26	28	29	30	31	32	34	35	36	12	
	16	19	21	22	24	26	27	29	30	32	34	35	37	38	40	42	43	45	46	48	16	
	20	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	20	
150	8	14	16	17	18	19	20	22	23	24	25	26	28	29	30	31	32	34	35	36	8	150
	12	22	23	25	27	29	31	32	34	36	38	40	41	43	45	47	49	50	52	54	12	
	16	29	31	34	36	38	41	43	46	48	50	53	55	58	60	63	65	67	70	72	16	
	20	36	39	42	45	48	51	54	57	60	63	66	69	72	75	78	81	84	87	90	20	
200	8	19	21	22	24	26	27	29	30	32	34	35	37	38	40	42	43	45	46	48	8	200
	12	29	31	34	36	38	41	43	46	48	50	53	55	58	60	62	65	67	70	72	12	
	16	38	42	45	48	51	54	58	61	64	67	70	74	77	80	83	87	90	93	96	16	
	20	48	52	56	60	64	68	72	76	80	84	88	92	96	100	104	108	112	116	120	20	
300	8	29	31	34	36	38	41	43	46	48	50	53	55	58	60	62	65	67	70	72	8	300
	12	43	47	50	54	58	61	65	68	72	76	79	83	87	90	94	97	101	105	108	12	
	16	58	62	67	72	77	82	86	91	96	101	106	110	115	120	125	130	135	139	144	16	
	20	72	78	84	90	96	102	108	114	120	126	132	138	144	150	156	162	168	174	180	20	
400	8	38	42	45	48	51	54	58	61	64	67	70	74	77	80	83	86	90	93	96	8	400
	12	58	62	67	72	77	82	86	91	96	101	106	110	115	120	125	130	134	139	144	12	
	16	77	83	90	96	102	108	115	121	128	135	141	147	153	160	167	173	180	186	192	16	
	20	96	104	112	120	128	136	144	152	160	168	176	184	192	200	208	216	224	232	240	20	
500	8	48	52	56	60	64	68	72	76	80	84	88	92	96	100	104	108	112	116	120	8	500
	12	72	78	84	90	96	102	108	114	120	126	132	138	144	150	156	162	168	174	180	12	
	16	96	104	112	120	128	136	144	152	160	168	176	184	192	200	208	216	224	232	240	16	
	20	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	20	

REQUIRED THICKNESS

P	L	Req'd Thickness, for "b" as Given													
		3	4	5	6	7	8	9	10	11	12	13	14	15	16
100	12	¾	¾	⅝	⅝	½	½	½							
	14	⅞	⅞	¾	¾	¾	⅝	⅝	½	½					
	16	1	1	⅞	⅞	⅞	¾	¾	¾	⅝	⅝	½			
	18	1⅛	1⅛	1	1	1	⅞	⅞	⅞	¾	¾	⅝	⅝	½	
	20	1¼	1¼	1⅛	1⅛	1⅛	1	1	1	⅞	⅞	⅞	¾	¾	⅝
	22	1⅜	1⅜	1¼	1¼	1¼	1¼	1⅛	1⅛	1⅛	1	1	⅞	⅞	¾
	24	1½	1½	1⅜	1⅜	1⅜	1⅜	1¼	1¼	1¼	1⅛	1⅛	1	1	1
	26	1⅝	1⅝	1½	1½	1½	1½	1⅜	1⅜	1⅜	1¼	1¼	1¼	1⅛	1⅛
	28	1¾	1¾	1¾	1⅝	1⅝	1⅝	1½	1½	1½	1⅜	1⅜	1⅜	1¼	1¼
	30	1⅞	1⅞	1⅞	1¾	1¾	1¾	1⅝	1⅝	1⅝	1½	1½	1½	1⅜	1⅜
150	12	⅞	⅞	¾	¾	⅝	⅝	½	½						
	14	1	1	1	⅞	⅞	¾	¾	⅝	⅝	½				
	16	1¼	1⅛	1⅛	1	1	1	⅞	⅞	¾	¾	⅝	½		
	18	1⅜	1⅜	1¼	1¼	1⅛	1⅛	1⅛	1	1	⅞	¾	¾	⅝	½
	20	1½	1½	1⅜	1⅜	1⅜	1¼	1¼	1⅛	1⅛	1	1	⅞	⅞	¾
	22	1⅝	1⅝	1⅝	1½	1½	1½	1⅜	1⅜	1¼	1¼	1⅛	1⅛	1	1
	24	1⅞	1¾	1¾	1¾	1⅝	1⅝	1½	1½	1½	1⅜	1⅜	1¼	1¼	1⅛
	26	2	2	1⅞	1⅞	1¾	1¾	1¾	1⅝	1⅝	1⅝	1½	1½	1⅜	1⅜
	28	2⅛	2⅛	2	2	2	1⅞	1⅞	1⅞	1¾	1¾	1⅝	1⅝	1⅝	1½
	30	2¼	2¼	2¼	2⅛	2⅛	2⅛	2	2	2	1⅞	1⅞	1¾	1¾	1⅝
200	12	1	1	⅞	⅞	¾	¾	⅝	½						
	14	1¼	1⅛	1⅛	1	1	⅞	⅞	¾	⅝	½				
	16	1⅜	1⅜	1¼	1¼	1⅛	1⅛	1	1	⅞	¾	¾	⅝	½	
	18	1½	1½	1½	1⅜	1⅜	1¼	1¼	1⅛	1⅛	1	⅞	⅞	¾	⅝
	20	1¾	1¾	1⅝	1⅝	1½	1½	1⅜	1⅜	1¼	1¼	1⅛	1	1	⅞
	22	1⅞	1⅞	1⅞	1¾	1¾	1⅝	1⅝	1½	1½	1⅜	1⅜	1¼	1¼	1⅛
	24	2⅛	2	2	2	1⅞	1⅞	1¾	1¾	1⅝	1⅝	1½	1½	1⅜	1⅜
	26	2¼	2¼	2⅛	2⅛	2⅛	2	2	1⅞	1⅞	1¾	1¾	1⅝	1⅝	1½
	28	2½	2⅜	2⅜	2¼	2¼	2¼	2⅛	2⅛	2	2	1⅞	1⅞	1¾	1¾
	30	2⅝	2⅝	2½	2½	2½	2⅜	2⅜	2¼	2¼	2⅛	2⅛	2	2	1⅞

P	L	Req'd Thickness, for "b" as Given													
		3	4	5	6	7	8	9	10	11	12	13	14	15	16
300	12	1¼	1⅛	1⅛	1	⅞	⅞	¾	⅝						
	14	1½	1⅜	1⅜	1¼	1⅛	1⅓	1	⅞	¾	⅝				
	16	1⅝	1⅝	1½	1½	1⅜	1⅜	1¼	1⅛	1	1	⅞	¾		
	18	1⅞	1⅞	1¾	1¾	1⅝	1½	1½	1⅜	1⅜	1¼	1⅛	1	⅞	¾
	20	2⅛	2	2	1⅞	1⅞	1¾	1¾	1⅝	1½	1½	1⅜	1¼	1⅛	1
	22	2⅜	2¼	2¼	2⅛	2⅛	2	2	1⅞	1¾	1¾	1⅝	1½	1½	1⅜
	24	2⅝	2½	2½	2⅜	2⅜	2¼	2⅛	2⅛	2	2	1⅞	1¾	1¾	1⅝
	26	2¾	2¾	2⅝	2⅝	2½	2½	2⅜	2⅜	2¼	2¼	2⅛	2	2	1⅞
	28	3	3	2⅞	2⅞	2¾	2¾	2⅝	2½	2½	2⅜	2⅜	2¼	2¼	2⅛
	30	3¼	3⅛	3⅛	3	3	2⅞	2⅞	2¾	2¾	2⅝	2½	2½	2⅜	2⅜
400	12	1⅜	1⅜	1¼	1⅛	1	1	⅞	¾						
	14	1⅝	1⅝	1½	1⅜	1⅜	1¼	1⅛	1	⅞	¾				
	16	1⅞	1⅞	1¾	1¾	1⅝	1½	1⅜	1⅜	1¼	1⅛	1	¾		
	18	2⅛	2⅛	2	2	1⅞	1¾	1¾	1⅝	1½	1⅜	1¼	1⅛	1	⅞
	20	2½	2⅜	2¼	2¼	2⅛	2	2	1⅞	1¾	1¾	1⅝	1½	1⅜	1¼
	22	2¾	2⅝	2½	2½	2⅜	2⅜	2¼	2⅛	2⅛	2	1⅞	1¾	1⅝	1½
	24	3	2⅞	2⅞	2¾	2⅝	2⅝	2½	2⅜	2⅜	2¼	2⅛	2	2	1⅞
	26	3¼	3⅛	3⅛	3	2⅞	2⅞	2¾	2¾	2⅝	2½	2⅜	2⅜	2¼	2⅛
	28	3½	3⅜	3⅜	3¼	3⅛	3⅛	3	3	2⅞	2¾	2¾	2⅝	2½	2⅜
	30	3¾	3⅝	3⅝	3½	3½	3⅜	3¼	3¼	3⅛	3	3	2⅞	2¾	3¾
500	12	1½	1½	1⅜	1¼	1⅛	1	⅞	¾						
	14	1⅞	1¾	1⅝	1⅝	1½	1⅜	1¼	1⅛	1	⅞				
	16	2⅛	2	2	1⅞	1¾	1¾	1⅝	1½	1⅜	1¼	1	⅞		
	18	2⅜	2⅜	2¼	2⅛	2⅛	2	1⅞	1¾	1⅝	1½	1⅜	1¼	1⅛	1
	20	2¾	2⅝	2½	2½	2⅜	2¼	2¼	2⅛	2	1⅞	1¾	1⅝	1½	1⅜
	22	3	2⅞	2⅞	2¾	2⅝	2⅝	2½	2⅜	2¼	2¼	2⅛	2	1⅞	1¾
	24	3¼	3¼	3⅛	3	3	2⅞	2¾	2¾	2⅝	2½	2⅜	2¼	2⅛	2
	26	3⅝	3½	3⅜	3⅜	3¼	3⅛	3⅛	3	2⅞	2¾	2¾	2⅝	2½	2⅜
	28	3⅞	3¾	3¾	3⅝	3½	3½	3⅜	3¼	3¼	3⅛	3	2⅞	2¾	2¾
	30	4⅛	4⅛	4	3⅞	3⅞	3¾	3⅝	3⅝	3½	3⅜	3⅜	3¼	3⅛	3

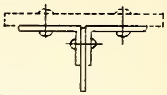




GIRDER FLANGE ANGLES

FOR PLATE GIRDERS

NET AND GROSS AREAS, WEIGHTS, ETC.



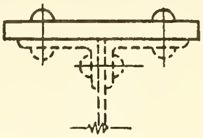
FOR USE IN DESIGNING PLATE GIRDERS BY CHORD STRESS OR FLANGE AREA

ANGLE		2 ANGLES NO HOLES OUT				NET AREA—2 ANGLES; 1-HOLE OUT EACH ANGLE, FOR SIZE RIVET SHOWN					NET AREA—2 ANGLES; 2-HOLE OUT EACH ANGLE, FOR SIZE RIVET SHOWN				
SIZE	THICK	WT. LBS. FT.	AREA SQ. IN.	"X"	"Y"	¾″	⅞″	1″	1⅛″	1¼″	¾″	⅞″	1″	1⅛″	1¼″
5 x 3½	¼	13.2	3.9	1.56	0.81	3.5	3.4	3.3			3.0	2.9			
	5/16	17.4	5.1	1.59	0.84	4.6	4.5	4.4			4.0	3.9			
	⅜	20.8	6.1	1.61	0.86	5.4	5.3	5.3			4.8	4.6			
	7/16	24.0	7.1	1.63	0.88	6.3	6.2	6.1			5.5	5.3			
	½	27.2	8.0	1.66	0.91	7.1	7.0	6.9			6.3	6.0			
	⅝	33.6	9.8	1.70	0.95	8.7	8.6	8.4			7.7	7.3			
	¾	39.6	11.6	1.75	1.00	10.3	10.1	9.9			9.0	8.6			
6 x 4	5/16	20.6	6.1	1.92	0.92	5.6	5.5	5.4	5.3		5.0	4.9	4.7	4.5	
	⅜	24.6	7.2	1.94	0.94	6.6	6.5	6.4	6.3		5.9	5.7	5.5	5.3	
	7/16	28.6	8.4	1.96	0.96	7.6	7.5	7.4	7.3		6.8	6.6	6.4	6.2	
	½	32.4	9.5	1.99	0.99	8.6	8.5	8.4	8.3		7.8	7.5	7.3	7.0	
	9/16	36.2	10.6	2.01	1.01	9.6	9.5	9.4	9.2		8.7	8.4	8.1	7.8	
	⅝	40.0	11.7	2.03	1.03	10.6	10.5	10.4	10.2		9.5	9.2	8.9	8.6	
	¾	47.2	13.9	2.08	1.08	12.6	12.4	12.2	12.0		11.3	10.9	10.5	10.1	
	⅞	54.4	16.0	2.12	1.12	14.4	14.2	14.0	13.8		12.9	12.5	12.0	11.6	
6 x 6	5/16	25.2	7.3	1.61	1.61	6.8	6.7	6.6	6.3	6.2	6.2	6.1	5.9	5.7	
	⅜	29.8	8.7	1.64	1.64	8.1	8.0	7.9	7.8	7.7	7.4	7.2	7.0	6.8	
	7/16	34.4	10.1	1.66	1.66	9.4	9.2	9.1	9.0	8.9	8.6	8.4	8.2	7.9	
	½	39.2	11.5	1.68	1.68	10.6	10.5	10.4	10.2	10.1	9.8	9.5	9.3	9.0	
	9/16	43.8	12.9	1.71	1.71	11.9	11.7	11.6	11.5	11.4	10.9	10.6	10.3	10.1	
	⅝	48.4	14.2	1.73	1.73	13.1	13.0	12.8	12.7	12.5	12.0	11.7	11.4	11.1	
	¾	57.4	16.9	1.78	1.78	15.6	15.4	15.2	15.0	14.8	14.3	13.9	13.5	13.1	
	⅞	66.2	19.5	1.82	1.82	17.9	17.7	17.5	17.3	17.0	16.4	16.0	15.5	15.1	
	1	74.8	22.0	1.86	1.86	20.3	20.0	19.7	19.5	19.2	18.5	18.0	17.5	16.8	
7 x 4	⅜	27.2	8.0	2.37	0.87	7.3	7.2	7.1	7.0	7.0	6.7	6.5	6.3	6.1	
	7/16	31.6	9.3	2.39	0.89	8.5	8.4	8.3	8.2	8.1	7.7	7.5	7.3	7.1	
	½	35.8	10.5	2.42	0.92	9.6	9.5	9.4	9.3	9.2	8.8	8.5	8.3	8.0	
	9/16	40.0	11.8	2.44	0.94	10.8	10.6	10.5	10.3	10.3	9.8	9.5	9.2	8.9	
	⅝	44.2	13.0	2.46	0.96	11.9	11.7	11.6	11.4	11.3	10.8	10.5	9.8	9.7	
	¾	52.4	15.4	2.51	1.01	14.1	13.9	13.7	13.5	13.4	12.8	12.4	12.0	11.6	
	⅞	60.4	17.7	2.55	1.05	16.2	16.0	15.8	15.5	15.3	14.7	14.2	13.8	13.3	
8 x 4	7/16	34.4	10.1	2.83	1.09	9.4	9.2	9.1	9.0	8.9	8.6	8.4	8.2	7.9	
	½	39.2	11.5	2.86	1.08	10.6	10.5	10.4	10.3	10.2	9.8	9.5	9.3	9.0	
	9/16	43.8	12.8	2.88	1.07	11.9	11.7	11.6	11.5	11.4	10.9	10.6	10.3	10.1	
	⅝	48.4	14.2	2.91	1.07	13.1	13.0	12.8	12.7	12.6	12.0	11.7	11.4	11.1	
	¾	57.4	16.9	2.95	1.05	15.6	15.4	15.2	15.0	14.8	14.3	13.9	13.5	13.1	
	⅞	66.2	19.5	3.00	1.04	17.9	17.7	17.5	17.3	17.1	16.4	16.0	15.5	15.1	
	1	74.8	22.0	3.05	1.03	20.3	20.0	19.8	19.5	19.4	18.5	18.0	17.5	17.0	
8 x 6	7/16	40.4	11.9	2.45	1.45	11.1	11.0	10.9	10.8	10.7	10.3	10.1	9.9	9.7	
	½	46.0	13.5	2.47	1.47	12.6	12.5	12.4	12.2	12.1	11.8	11.5	11.3	11.0	
	9/16	51.4	15.1	2.50	1.50	14.1	14.0	13.9	13.7	13.6	13.2	12.9	12.6	12.3	
	⅝	57.0	16.7	2.52	1.52	15.6	15.5	15.3	15.2	15.0	14.5	14.2	13.9	13.6	
	¾	67.6	19.9	2.56	1.56	18.6	18.4	18.2	18.0	17.8	17.3	16.9	16.5	16.1	
	⅞	78.2	23.0	2.61	1.61	21.4	21.2	21.0	20.8	20.5	19.9	19.5	19.0	18.6	
	1	88.4	26.0	2.65	1.65		24.0	23.7	23.5	23.2	22.5	22.0	21.5	21.0	
8 x 8	½	52.8	15.5	2.19	2.19	14.6	14.5	14.4	14.2	14.1	13.8	13.5	13.3	13.0	12.7
	9/16	59.2	17.4	2.21	2.21	16.4	16.2	16.1	16.0	15.9	15.4	15.1	14.8	14.6	14.4
	⅝	65.4	19.2	2.23	2.23	18.1	18.0	17.8	17.7	17.5	17.0	16.7	16.4	16.1	15.8
	¾	77.8	22.9	2.28	2.28	21.6	21.4	21.2	21.0	20.8	20.3	19.9	19.5	19.1	18.8
	⅞	90.0	26.5	2.32	2.32	24.9	24.7	245.0	24.3	28.0	23.4	23.0	22.5	22.1	21.7
	1	102.0	30.0	2.37	2.37	28.3	28.0	27.7	27.5	27.2	26.5	26.0	25.5	25.0	24.5
	1⅛	113.8	33.5	2.41	2.41	31.5	31.2	30.9	30.6	30.4	29.5	29.0	28.4	27.8	27.2
9 x 4	½	42.6	12.5	2.92	0.81	11.6	11.5	11.4	11.3	11.1	10.8	10.5	10.3	10.0	9.8
	9/16	47.6	14.0	2.91	0.83	13.0	12.9	12.7	12.6	12.5	12.0	11.8	11.5	11.2	11.0
	⅝	52.6	15.5	2.90	0.86	14.4	14.2	14.1	13.9	13.8	13.3	13.0	12.7	12.3	12.0
	¾	62.6	18.4	2.88	0.91	17.1	16.9	16.7	16.5	16.3	15.8	15.4	15.0	14.6	14.3
	⅞	72.2	21.2	2.86	0.95	19.7	19.5	19.3	19.0	18.8	18.2	17.7	17.3	16.8	16.4
	1	81.6	24.0	2.84	1.00	22.3	22.0	21.8	21.5	21.2	20.5	20.0	19.5	19.0	18.5

GIRDER COVER PLATES

FOR PLATE GIRDERS

NET AND GROSS AREAS, WEIGHTS, ETC.



FOR USE IN DESIGNING PLATE GIRDERS BY CHORD STRESS OR FLANGE AREA METHOD

AREA SQ. IN.	RIVET DIAM.	WIDTH OF PLATE	TOTAL THICKNESS OF COVER PLATE, INCHES																						
			⅜	7/16	½	9/16	⅝	11/16	¾	13/16	⅞	15/16	1	1⅛	1¼	1⅜	1½	1⅝	1¾	1⅞	2	2¼	2½	2¾	3
GROSS AREA	NO RIVETS	12	4.5	5.3	6.0	6.8	7.5	8.3	9.0	9.8	10.5	11.3	12.0	13.5	15.0	16.5	18.0	19.5	21.0	22.5	24.0	27.0	30.0	33.0	36.0
		14	5.3	6.1	7.0	7.9	8.8	9.6	10.5	11.4	12.3	13.1	14.0	15.8	17.5	19.3	21.0	22.8	24.5	26.3	28.0	31.5	35.0	38.5	42.0
		16	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0	30.0	32.0	36.0	40.0	44.0	48.0
		18	6.8	7.9	9.0	10.1	11.3	12.4	13.5	14.6	15.8	16.9	18.0	20.3	22.5	24.8	27.0	29.3	31.5	33.8	36.0	40.5	45.0	49.5	54.0
		20	7.5	8.8	10.0	11.3	12.5	13.8	15.0	16.3	17.5	18.8	20.0	22.5	25.0	27.5	30.0	32.5	35.0	37.5	40.0	45.0	50.0	55.0	60.0
		22	8.3	9.6	11.0	12.4	13.8	15.1	16.5	17.9	19.3	20.6	22.0	24.8	27.5	30.3	33.0	35.8	38.5	41.3	44.0	49.5	55.0	60.5	66.0
		24	9.0	10.5	12.0	13.5	15.0	16.5	18.0	19.5	21.0	22.5	24.0	27.0	30.0	33.0	36.0	39.0	42.0	45.0	48.0	54.0	60.0	66.0	72.0
NET AREA — ONE HOLE OUT	¾″	12	4.2	4.9	5.6	6.3	7.0	7.7	8.3	9.0	9.7	10.4	11.1	12.5	13.9	15.3	16.7	18.1	19.5	20.9	22.2	25.0	27.8	30.6	33.4
		14	4.9	5.7	6.6	7.4	8.2	9.0	9.8	10.7	11.5	12.3	13.1	14.8	16.4	18.1	19.7	21.3	23.0	24.6	26.2	29.5	32.8	36.1	39.4
		16	5.7	6.6	7.6	8.5	9.5	10.4	11.3	12.3	13.2	14.2	15.1	17.0	18.9	20.8	22.7	24.6	26.5	28.4	30.2	34.0	37.8	41.6	45.4
		18	6.4	7.5	8.6	9.6	10.7	11.8	12.8	13.8	15.0	16.1	17.1	19.3	21.4	23.6	25.7	27.8	30.0	32.1	34.2	38.5	42.8	47.1	51.4
	⅞″	12	4.1	4.8	5.5	6.2	6.9	7.6	8.3	8.9	9.6	10.3	11.0	12.4	13.8	15.1	16.5	17.9	19.3	20.6	22.0	24.8	27.5	30.3	33.0
		14	4.9	5.7	6.5	7.3	8.1	8.9	9.8	10.6	11.4	12.2	13.0	14.6	16.3	17.9	19.5	21.1	22.8	24.4	26.0	29.3	32.5	35.8	39.0
		16	5.6	6.6	7.5	8.4	9.4	10.3	11.3	12.2	13.1	14.1	15.0	16.9	18.8	20.6	22.5	24.4	26.3	28.1	30.0	33.8	37.5	41.3	45.0
		18	6.4	7.4	8.5	9.6	10.6	11.7	12.8	13.7	14.9	15.9	17.0	19.1	21.3	23.4	25.5	27.6	29.8	31.9	34.0	38.3	42.5	46.8	51.0
NET AREA — TWO HOLES OUT	¾″	12	3.8	4.5	5.1	5.8	6.4	7.0	7.7	8.3	9.0	9.6	10.3	11.5	12.8	14.1	15.4	16.6	17.9	19.2	20.5	23.0	25.6	28.2	30.8
		14	4.6	5.4	6.1	6.9	7.7	8.4	9.2	10.0	10.7	11.5	12.3	13.8	15.3	16.9	18.4	19.9	21.4	23.0	24.5	27.5	30.6	33.7	36.8
		16	5.3	6.2	7.1	8.0	8.9	9.8	10.7	11.6	12.5	13.4	14.3	16.0	17.8	19.6	21.4	23.1	24.9	26.7	28.5	32.0	35.6	39.2	42.8
		18	6.1	7.1	8.1	9.1	10.2	11.2	12.2	13.2	14.3	15.3	16.3	18.3	20.3	22.4	24.4	26.4	28.4	30.5	33.5	36.5	40.6	44.7	48.8
	⅞″	12	3.8	4.4	5.0	5.6	6.3	6.9	7.5	8.1	8.8	9.4	10.0	11.2	12.5	13.7	15.0	16.2	17.5	18.8	20.0	22.5	25.0	27.5	30.0
		14	4.5	5.3	6.0	6.8	7.5	8.3	9.0	9.8	10.5	11.3	12.0	13.5	15.0	16.5	18.0	19.5	21.0	22.5	24.0	27.0	30.0	33.0	36.0
		16	5.3	6.1	7.0	7.9	8.8	9.6	10.5	11.4	12.3	13.1	14.0	15.7	17.5	19.2	21.0	22.7	24.5	26.3	28.0	31.5	35.0	38.5	42.0
		18	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0	30.0	32.0	36.0	40.0	44.0	48.0
	1″	12	3.7	4.3	4.9	5.5	6.1	6.8	7.3	8.0	8.5	9.2	9.7	11.0	12.2	13.4	14.6	15.8	17.1	18.3	19.5	21.9	24.4	26.8	29.3
		14	4.4	5.1	5.9	6.6	7.3	8.1	8.8	9.5	10.3	11.0	11.8	13.2	14.7	16.2	17.6	19.1	20.6	22.0	23.5	26.4	29.4	32.3	35.3
		16	5.2	6.0	6.9	7.7	8.6	9.5	10.3	11.2	12.0	12.9	13.8	15.5	17.2	18.9	20.6	22.3	24.1	25.8	27.5	30.9	34.4	37.8	41.3
		18	5.9	6.9	7.9	8.9	9.8	10.8	11.8	12.8	13.8	14.8	15.8	17.7	19.7	21.7	23.6	25.6	27.6	29.5	31.5	35.4	39.4	43.3	47.3
		20	6.7	7.8	8.9	10.0	11.1	12.2	13.3	14.4	15.5	16.6	17.8	20.0	22.2	24.4	26.6	28.8	31.1	33.3	35.5	39.9	44.4	48.8	53.3
		22	7.4	8.6	9.9	11.1	12.3	13.6	14.8	16.0	17.3	18.5	19.8	22.2	24.7	27.2	29.6	32.1	34.6	37.0	39.5	44.4	49.4	54.3	59.3
		24	8.2	9.5	10.9	12.2	13.6	15.0	16.3	17.7	19.0	20.4	21.8	24.5	27.2	29.9	32.6	35.3	38.1	40.8	43.5	48.9	54.4	59.8	65.3
	1⅛″	16	5.1	5.9	6.7	7.6	8.4	9.3	10.1	11.0	11.8	12.7	13.5	15.2	16.9	18.6	20.2	21.9	23.6	25.3	27.0	30.4	33.7	37.1	40.5
		18	5.8	6.8	7.7	8.7	9.7	10.7	11.6	12.6	13.6	14.5	15.5	17.4	19.4	21.3	23.2	25.2	27.1	29.1	31.0	34.9	38.7	42.6	46.5
		20	6.6	7.7	8.8	9.8	10.9	12.0	13.1	14.2	15.3	16.4	17.5	19.7	21.9	24.1	26.3	28.4	30.6	32.8	35.0	39.4	43.8	48.1	52.5
		22	7.3	8.5	9.8	11.0	12.2	13.4	14.6	15.8	17.1	18.3	19.5	21.9	24.4	26.8	29.3	31.7	34.1	36.6	39.0	43.9	48.8	53.6	58.5
		24	8.1	9.4	10.8	12.1	13.4	14.8	16.1	17.5	18.8	20.2	21.5	24.2	26.9	29.6	32.3	34.9	37.6	40.3	43.0	48.4	53.8	59.1	64.5
	1¼″	16	5.0	5.8	6.6	7.5	8.3	9.1	9.9	10.8	11.6	12.4	13.3	14.9	16.5	18.2	19.9	21.5	23.2	24.8	26.5	29.8	33.1	36.4	39.8
		18	5.7	6.7	7.6	8.6	9.5	10.5	11.4	12.4	13.3	14.3	15.3	17.2	19.0	21.0	22.9	24.8	26.7	28.6	30.5	34.3	38.1	41.9	45.8
		20	6.5	7.5	8.6	9.7	10.8	11.9	12.9	14.0	15.1	16.2	17.3	19.4	21.6	23.7	25.9	28.0	30.2	32.3	34.5	38.8	43.1	47.4	51.8
		22	7.2	8.4	9.6	10.8	12.0	13.2	14.4	15.6	16.8	18.0	19.3	21.7	24.1	26.5	28.9	31.3	33.7	36.1	38.5	43.3	48.1	52.9	57.8
		24	8.0	9.3	10.6	12.0	13.3	14.6	15.9	17.3	18.6	19.9	21.3	23.9	26.6	29.2	31.9	34.5	37.2	39.8	42.5	47.8	53.1	58.4	63.8
WEIGHT PER FOOT		12	15.3	17.9	20.4	23.0	25.5	28.1	20.6	33.2	35.7	38.3	40.8	45.9	51.0	56.1	61.2	66.3	71.4	76.5	81.6	91.8	102	112	122
		14	17.9	20.8	23.8	26.8	29.8	32.7	35.7	38.7	41.7	44.6	47.6	54.0	59.5	65.5	71.4	77.4	83.3	89.3	95.2	107	119	131	143
		16	20.4	23.8	27.2	30.6	34.0	37.4	40.8	44.2	47.6	51.0	54.4	62.1	68.0	74.8	81.6	88.4	95.2	102	109	122	136	150	163
		18	23.0	26.8	30.6	34.4	38.3	42.1	45.9	49.7	53.6	57.4	61.2	70.1	76.5	84.2	91.8	99.5	107	115	122	138	153	168	184
		20	25.5	29.8	34.0	38.3	42.5	46.8	51.0	55.3	59.5	63.8	68.0	78.2	85.0	93.5	102	111	119	128	136	153	170	187	204
		22	28.1	32.7	37.4	42.1	46.8	51.4	56.1	60.8	65.5	70.1	74.8	86.3	93.5	103	112	122	131	140	150	168	187	206	224
		24	30.6	35.7	40.8	45.9	51.0	56.1	61.2	66.3	71.4	76.5	81.6	94.4	102	112	122	133	143	153	163	184	204	224	245

AREA OF ⅛ WEB PLATE FOR USE IN FLANGE

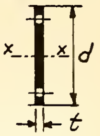
WEB THICKNESS	DEPTH OF WEB PLATE, INCHES																						
	24	26	28	30	32	34	36	38	40	42	44	46	48	54	60	66	72	78	84	90	96	108	120
5/16	.9	1.0	1.1	1.2	1.3	1.3	1.4	1.5	1.6	1.6	1.7	1.8	1.9	2.1	2.3	2.6	2.8	3.0	3.3	3.5	3.8	4.2	4.7
⅜	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.5	2.8	3.1	3.4	3.7	3.9	4.2	4.5	5.1	5.6
7/16	1.3	1.4	1.5	1.6	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	3.0	3.3	3.6	3.9	4.3	4.6	4.9	5.3	5.8	6.6
½	1.5	1.6	1.8	1.9	2.0	2.1	2.3	2.4	2.5	2.6	2.8	2.9	3.0	3.4	3.8	4.1	4.5	4.9	5.3	5.6	6.0	6.8	7.5
9/16	1.7	1.8	2.0	2.1	2.3	2.4	2.5	2.7	2.8	3.0	3.1	3.2	3.4	3.8	4.2	4.6	5.1	5.5	5.9	6.3	6.8	7.6	8.4
⅝	1.9	2.0	2.2	2.3	2.5	2.7	2.8	3.0	3.1	3.3	3.4	3.6	3.8	4.2	4.7	5.2	5.6	6.1	6.6	7.0	7.5	8.4	9.4
11/16	2.1	2.2	2.4	2.6	2.8	2.9	3.1	3.3	3.4	3.6	3.8	4.0	4.1	4.6	5.2	5.7	6.2	6.7	7.2	7.7	8.3	9.3	10.3
¾	2.3	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	3.9	4.1	4.3	4.5	5.1	5.6	6.2	6.8	7.3	7.9	8.4	9.0	10.1	11.3
13/16	2.4	2.6	2.8	3.0	3.3	3.5	3.7	3.9	4.1	4.3	4.5	4.7	4.9	5.5	6.1	6.7	7.3	7.9	8.5	9.1	9.8	11.0	12.2
⅞	2.6	2.8	3.1	3.3	3.5	3.7	3.9	4.2	4.4	4.6	4.8	5.0	5.3	5.9	6.6	7.2	7.9	8.5	9.2	9.9	10.5	11.8	13.6
15/16	2.8	3.0	3.3	3.5	3.8	4.0	4.2	4.5	4.7	4.9	5.2	5.4	5.6	6.3	7.0	7.7	8.4	9.1	9.9	10.5	11.3	12.7	14.1
1	3.0	3.3	3.5	3.8	4.0	4.3	4.5	4.8	5.0	5.3	5.5	5.8	6.0	6.8	7.5	8.3	9.0	9.8	10.5	11.3	12.0	13.5	15.0

Net Moments of Inertia given are for 13/16" holes out, for various size flange angles.

PLATE GIRDERS

MOMENTS OF INERTIA OF WEB PLATES

AXIS X-X



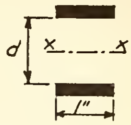
"d"	I	ANGLE LEG	Thickness, "t", in Inches							
			1/16	¼	⅜	½	⅝	¾	⅞	1
8	GROSS		2.7	10	15	20	25	30	35	45
	NET	2½	1.8	7	10	15	20	20	25	30
		3	2.0	8	10	15	20	25	25	30
9	GROSS		3.8	15	25	30	40	45	55	60
	NET	2½	2.8	10	15	20	25	30	35	40
		3	2.8	10	15	20	30	35	40	45
10	GROSS		5.2	20	30	40	50	65	75	85
	NET	2½	3.6	15	20	30	35	45	50	55
		3	3.9	15	25	30	40	45	55	60
11	GROSS		7.0	30	40	55	70	85	95	110
	NET	2½	4.9	20	30	40	50	60	70	75
		3	5.2	20	30	40	50	60	70	85
12	GROSS		9.0	35	55	70	90	110	125	145
	NET	2½	6.4	25	40	50	65	75	90	100
		3	6.8	25	40	55	70	80	95	110
		3½	7.0	30	40	55	70	85	100	115
		4-6	7.5	30	45	60	75	90	105	120
14	GROSS		14.3	55	85	115	145	170	200	230
	NET	2½	10.5	40	65	85	105	125	145	170
		3	11.0	40	65	85	110	130	155	175
		3½	11.3	40	70	90	115	135	160	180
		4-6	11.8	35	70	95	120	140	165	190
16	GROSS		21.3	85	130	170	215	255	300	340
	NET	2½	16.1	65	95	130	160	195	225	260
		3	16.7	65	100	135	165	200	235	265
		3½	17.0	70	100	140	170	205	240	275
		4-6	17.7	70	105	145	175	215	250	285
18	GROSS		30.4	120	180	245	305	365	425	485
	NET	2½	23.6	95	140	190	235	285	330	375
		3	24.2	95	145	195	240	290	340	385
		3½	24.7	100	145	200	245	295	345	395
		4-6	25.4	100	150	205	255	305	355	405
20	GROSS		41.7	165	250	335	415	500	585	665
	NET	2½	33.1	135	200	265	330	395	465	530
		3	33.8	135	205	270	340	405	475	540
		3½	34.3	135	205	275	345	410	480	550
		4-6	35.1	140	210	280	350	420	490	560
22	GROSS		55.5	220	335	445	555	665	775	885
	NET	2½	44.8	180	270	360	450	540	625	715
		3	45.6	180	275	365	455	545	640	730
		3½	46.1	185	280	370	460	555	645	740
		4-6	47.1	190	285	375	470	565	660	750
24	GROSS		72.0	290	430	575	720	865	1010	1150
	NET	2½	59.1	235	355	470	590	710	825	945
		3	59.9	240	360	480	600	720	840	960
		3½	60.5	240	365	485	605	725	850	970
		4-6	61.6	245	370	495	615	740	860	985
		8	62.6	250	375	500	625	750	875	1000
26	GROSS		91.5	365	550	730	915	1100	1280	1465
	NET	2½	76.1	305	455	610	760	915	1065	1220
		3	77.0	310	460	615	770	925	1080	1235
		3½	77.7	310	465	620	780	935	1090	1245
		4-6	78.9	315	475	630	790	945	1105	1265
		8	80.0	320	480	640	800	960	1120	1280
28	GROSS		114.3	455	685	915	1145	1370	1600	1830
	NET	2½	96.2	385	575	770	960	1155	1345	1540
		3	97.2	390	585	780	970	1165	1360	1555
		3½	97.9	390	590	785	980	1175	1370	1565
		4-6	99.2	395	595	795	990	1190	1390	1585
		8	100.5	400	605	805	1005	1205	1405	1605
30	GROSS		140.6	565	845	1125	1405	1690	1970	2250
	NET	2½	119.5	480	720	955	1195	1435	1675	1915
		3	120.7	485	725	965	1205	1450	1690	1930
		3½	121.4	485	730	970	1215	1460	1700	1945
		4-6	122.8	490	735	985	1230	1475	1720	1965
		8	124.2	495	745	995	1240	1490	1740	1985
32	GROSS		170.7	685	1025	1365	1705	2050	2390	2730
	NET	3	147.7	590	885	1180	1475	1770	2065	2365
		3½	148.5	595	890	1190	1485	1780	2075	2375
		4-6	150.0	600	900	1200	1500	1800	2100	2400
		8	151.5	605	910	1210	1515	1820	2120	2425
34	GROSS		204.7	820	1230	1640	2045	2455	2865	3275
	NET	3	178.4	715	1070	1430	1785	2140	2500	2855
		3½	179.3	715	1075	1434	1795	2150	2510	2870
		4-6	180.9	725	1085	1450	1810	2170	2535	2895
		8	182.5	730	1095	1460	1825	2190	2555	2920
36	GROSS		243.0	970	1460	1945	2430	2915	3400	3890
	NET	3	213.2	855	1280	1705	2130	2560	2985	3410
		3½	214.1	860	1285	1715	2140	2570	3000	3425
		4-6	215.9	865	1295	1725	2160	2590	3025	3455
		8	217.6	870	1305	1740	2175	2610	3045	3480
38	GROSS		285.8	1140	1720	2290	2860	3430	4000	4570
	NET	3	252.3	1010	1510	2020	2520	3030	3530	4040
		3½	253.3	1010	1520	2030	2530	3040	3550	4050
		4-6	255.1	1020	1530	2040	2550	3060	3570	4080
		8	256.9	1030	1540	2060	2570	3080	3600	4110
40	GROSS		333.3	1330	2000	2670	3330	4000	4670	5330
	NET	3	295.9	1180	1780	2370	2960	3550	4140	4730
		3½	296.9	1190	1780	2380	2970	3560	4160	4750
		4-6	298.8	1200	1790	2390	2990	3590	4190	4780
		8	300.8	1210	1810	2410	3010	3610	4210	4810
42	GROSS		385.9	1540	2320	3090	3860	4630	5400	6170
	NET	3	344.3	1380	2070	2750	3440	4130	4820	5510
		3½	345.4	1380	2070	2760	3450	4150	4830	5520
		4-6	347.4	1390	2080	2780	3470	4170	4860	5560
		8	349.5	1400	2100	2800	3500	4190	4890	5590
44	GROSS		443.7	1780	2660	3550	4440	5320	6210	7100
	NET	3	397.7	1590	2390	3180	3980	4770	5570	6360
		3½	398.8	1600	2390	3190	3990	4790	5580	6380
		4-6	401.0	1600	2410	3210	4010	4810	5610	6420
		8	403.2	1610	2420	3230	4030	4840	5640	6450
46	GROSS		507.0	2030	3040	4060	5070	6080	7100	8110
	NET	3	456.4	1830	2740	3650	4560	5480	6390	7300
		3½	457.6	1830	2750	3660	4580	5490	6400	7320
		4-6	459.9	1840	2760	3680	4600	5520	6440	7360
		8	462.1	1850	2770	3700	4620	5550	6470	7400
48	GROSS		576.0	2300	3460	4610	5760	6910	8060	9220
	NET	3	520.6	2080	3130	4170	5210	6250	7290	8330
		3½	521.9	2090	3140	4180	5220	6260	7310	8350
		4-6	524.3	2100	3150	4190	5240	6290	7340	8390
		8	526.6	2110	3160	4210	5270	6320	7370	8430
54	GROSS		820.1	3280	4920	6560	8200	9840	11480	13120
	NET	3	749.0	3000	4490	5990	7490	8990	10490	11980
		3½	750.4	3000	4500	6000	7500	9010	10510	12010
		4-6	753.1	3010	4520	6030	7530	9040	10540	12050
		8	755.8	3020	4540	6050	7560	9070	10580	12090
60	GROSS		1125.0	4500	6750	9000	11250	13500	15750	18000
	NET	3	1036.2	4150	6220	8290	10360	12440	14510	16580
		3½	1037.7	4150	6230	8300	10380	12450	14530	16600
		4-6	1040.8	4160	6250	8330	10410	12490	14570	16650
		8	1043.8	4180	6260	8350	10440	12530	14620	16700
66	GROSS		1497.4	5990	8980	11980	14970	17970	20960	23960
	NET	3	1388.9	5560	8330	11110	13890	16670	19440	22220
		3½	1390.6	5570	8340	11120	13910	16690	19470	22250
		4-6	1394.0	5580	8360	11150	13940	16730	19510	22300
		8	1397.3	5590	8380	11180	13970	16770	19560	22360
72	GROSS		1944.0	7780	11660	15550	19440	23330	27220	31100
	NET	3	1813.8	7260	10880	14510	18140	21770	25390	29020
		3½	1815.7	7270	10890	14530	18160	21790	25420	29050
		4-6	1819.4	7280	10920	14550	18190	21830	25470	29110
		8	1823.1	7290	10940	14590	18230	21880	25530	29170
78	GROSS		2471.6	9890	14830	19770	24720	29660	34600	39550
	NET	3	2317.8	9270	13910	18540	23180	27810	32450	37090
		3½	2319.8	9280	13920	18560	23200	27840	32480	37120
		4-6	2323.9	9290	13940	18590	23240	27850	32520	37180
		8	2324.9	9300	13950	18600	23250	27900	32550	37200
84	GROSS		3087.0	12350	18520	24700	30870	37040	43220	49390
	NET	3	2907.6	11630	17450	23260	29080	34890	40710	46520
		3½	2909.8	11640	17460	23280	29100	34910	40740	46560
		4-6	2914.2	11660	17490	23310	29140	34970	40800	46630
		8	2918.5	11670	17510	23350	29190	35020	40860	46690
90	GROSS		3797.0	15190	22780	30380	37970	45560	53160	60750
	NET	4-6	3597.1	14390	21580	28780	35970	43160	50360	57550
		8	3601.8	14410	21610	28820	36020	43220	50430	57620
96	GROSS		4608.0	18430	27650	36860	46080	55300	64510	73730
	NET	8	4384.0	17540	26300	35070	43840	52610	61380	70150

To obtain gross moment of inertia of two cover plates, multiply width of plate in inches by tabulated value.

PLATE GIRDERS

MOMENTS OF INERTIA OF COVER PLATES

AXIS X-X

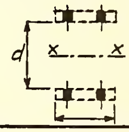


GROSS MOMENT OF INERTIA OF 2 PLATES 1" WIDE

"d"	Thickness of Plate, Inches																							
	¼	5/16	⅜	7/16	½	9/16	⅝	11/16	¾	13/16	⅞	15/16	1	1⅛	1¼	1⅜	1½	1⅝	1¾	1⅞	2	2¼	2½	3
8½	10	12	15	18	20	23	26	29	32	35	39	42	45	52	60	68	76							
9½	12	15	18	22	25	29	32	36	40	43	47	51	55	64	73	82	91	101						
10½	15	18	22	26	30	35	39	43	48	52	57	62	66	76	87	97	109	120	132					
11½	17	22	27	31	35	41	46	51	56	62	67	73	78	90	102	114	127	140	154	168				
12½	20	26	31	37	42	48	54	60	66	72	78	85	91	105	119	133	148	163	179	195	212			
14½	27	34	42	49	56	64	72	79	87	95	104	112	120	138	155	174	193	212	232	253	274	318	364	464
16½	35	44	53	63	72	82	92	102	112	122	132	143	153	175	197	220	244	268	292	318	344	397	454	575
18½	44	55	67	79	90	102	114	127	139	152	164	177	190	217	244	272	301	330	360	390	422	486	554	698
20½	54	68	82	96	110	125	140	154	169	185	200	216	231	263	296	329	364	398	434	470	508	584	664	833
22½	65	81	98	115	132	150	167	185	203	221	239	258	276	314	353	392	433	474	515	558	602	691	784	980
24½	77	96	116	136	156	177	197	218	239	260	282	304	325	370	415	461	508	555	604	653	704	807	914	1139
26½	89	112	135	159	182	206	230	254	279	303	328	353	378	430	482	535	589	643	699	756	814	932	1054	1310
28½	103	130	156	183	210	238	265	293	321	349	378	406	435	494	554	614	676	738	802	866	932	1066	1204	1493
30½	118	148	179	209	240	271	303	334	366	398	431	463	496	563	630	699	769	839	911	984	1058	1209	1364	1688
32½	134	168	203	237	272	308	343	379	415	451	487	524	561	636	712	789	868	947	1027	1109	1192	1360	1534	1895
34½	151	189	228	267	306	346	386	426	466	507	548	589	630	714	799	885	973	1061	1151	1242	1333	1521	1714	2114
36½	169	212	255	299	342	386	431	475	520	566	611	657	703	797	891	987	1084	1182	1282	1382	1484	1691	1904	2345
38½	188	235	283	332	380	429	478	528	578	628	678	729	780	883	988	1094	1201	1309	1418	1529	1642	1870	2104	2588
40½	208	260	313	367	420	474	529	583	638	693	749	805	861	975	1090	1206	1324	1443	1563	1685	1808	2058	2314	2843
42½	228	286	345	403	462	522	581	641	702	762	823	885	946	1071	1197	1324	1453	1583	1714	1847	1982	2255	2534	3110
44½	250	314	378	442	506	571	636	702	768	834	901	968	1035	1171	1309	1447	1588	1729	1873	2017	2164	2461	2764	3389
46½	273	342	412	482	552	623	694	766	837	910	982	1055	1128	1276	1425	1576	1729	1883	2038	2195	2354	2676	3004	3680
48½	297	372	448	524	600	677	754	832	910	988	1067	1146	1225	1386	1547	1711	1876	2042	2210	2380	2552	2899	3254	3983
54½	375	469	565	660	756	853	950	1047	1145	1243	1342	1441	1540	1741	1943	2147	2353	2560	2769	2981	3194	3625	4064	4964
60½	461	578	695	812	930	1049	1168	1287	1407	1527	1648	1770	1891	2136	2384	2633	2884	3137	3392	3649	3908	4432	4964	6053
66½	557	698	839	980	1122	1265	1408	1552	1696	1841	1986	2132	2278	2573	2869	3168	3469	3772	4077	4384	4694	5319	5954	7250
72½	662	828	996	1164	1332	1501	1671	1841	2012	2184	2356	2528	2701	3049	3400	3753	4108	4465	4825	5187	5552	6288	7034	8555
78½	775	971	1167	1363	1560	1758	1956	2156	2355	2556	2757	2958	3160	3567	3975	4387	4801	5217	5636	6058	6482	7338	8204	9968
84½	898	1124	1351	1578	1806	2035	2265	2495	2725	2957	3189	3422	3655	4124	4596	5070	5548	6027	6510	6995	7484	8468	9464	11489
90½	1029	1289	1548	1809	2070	2332	2595	2858	3123	3387	3653	3919	4186	4723	5262	5804	6349	6896	7447	8001	8558	9680	10814	13118
96½	1170	1465	1760	2056	2352	2650	2948	3247	3547	3847	4148	4451	4753	5361	5972	6586	7204	7824	8447	9074	9704	10972	12254	14855

Values given are based on ¾" rivets.

MOMENT OF INERTIA OF FOUR $\frac{13}{16}$" HOLES IN COVER PLATES



FOR NET I, DEDUCT VALUES BELOW FROM GROSS VALUES ABOVE

"d"	Thickness of Plate, Inches																							
	¼	5/16	⅜	7/16	½	9/16	⅝	11/16	¾	13/16	⅞	15/16	1	1⅛	1¼	1⅜	1½	1⅝	1¾	1⅞	2	2¼	2½	3
8½	15	20	25	30	35	40	45	50	55	60	65	70	80	90	105	115	130							
9½	20	25	30	40	45	50	55	65	70	75	80	90	95	110	125	145	160	175						
10½	25	30	40	45	55	60	70	75	85	90	100	110	115	130	150	170	190	210	230					
11½	30	40	45	55	65	70	80	90	100	110	120	130	135	160	180	200	220	245	270	290				
12½	35	45	55	65	75	85	95	105	115	125	135	150	160	180	210	230	255	285	310	340	365			
14½	50	60	75	85	100	110	125	140	150	165	180	195	210	240	270	305	335	370	405	440	475	550	630	805
16½	60	80	95	110	125	145	160	180	195	215	230	250	270	305	345	385	425	465	510	555	600	695	790	1000
18½	75	100	120	135	160	180	200	220	240	265	290	310	335	380	430	475	525	575	630	680	735	845	960	1215
20½	95	120	140	165	195	220	245	270	295	320	350	380	405	460	520	575	635	695	755	820	885	1020	1160	1450
22½	115	140	170	200	230	260	290	320	355	385	420	450	485	550	615	685	755	825	900	975	1050	1210	1370	1705
24½	135	170	205	240	270	310	345	380	420	455	495	530	570	645	725	810	890	970	1055	1140	1225	1410	1590	1985
26½	155	200	240	280	320	360	400	445	490	530	575	620	660	750	840	935	1030	1125	1220	1320	1420	1620	1840	2285
28½	180	230	275	320	370	415	465	510	565	610	660	710	760	865	970	1070	1180	1290	1400	1510	1630	1860	2100	2605
30½	205	260	310	370	420	475	530	585	640	700	750	810	870	990	1100	1220	1340	1470	1590	1720	1850	2110	2380	2945
32½	235	295	355	415	480	520	600	665	730	790	850	920	980	1110	1250	1380	1520	1660	1800	1940	2070	2380	2680	3310
34½	265	330	400	470	535	605	675	745	820	890	960	1030	1100	1250	1400	1550	1700	1860	2010	2170	2330	2660	2990	3690
36½	295	370	450	525	600	675	755	830	910	990	1070	1150	1230	1390	1560	1730	1900	2060	2240	2410	2590	2950	3330	4100
38½	330	410	495	580	665	750	835	920	990	1100	1190	1280	1370	1550	1730	1910	2100	2290	2480	2670	2870	3270	3680	4520
40½	365	455	550	640	735	830	925	1020	1120	1210	1310	1410	1510	1710	1910	2110	2310	2520	2730	2950	3160	3600	4040	4970
42½	400	500	605	710	810	910	1020	1120	1230	1330	1440	1550	1650	1870	2100	2320	2540	2760	3000	3230	3460	3940	4430	5430
44½	440	550	660	775	890	1000	1110	1230	1340	1460	1570	1700	1810	2050	2290	2530	2780	3020	3270	3530	3780	4300	4830	5920
46½	480	600	720	845	970	1090	1220	1340	1470	1590	1720	1850	1980	2230	2490	2760	3020	3290	3560	3840	4120	4680	5250	6430
48½	520	650	785	920	1050	1180	1320	1450	1590	1730	1870	2010	2150	2420	2710	2990	3280	3570	3860	4150	4460	5070	5690	6960
54½	660	820	990	1155	1320	1490	1660	1830	2000	2170	2350	2520	2700	3050	3400	3760	4110	4480	4850	5210	5590	6340	7110	8680
60½	810	1010	1220	1425	1630	1830	2040	2250	2460	2670	2880	3100	3310	3740	4160	4600	5050	5490	5930	6380	6840	7750	8680	10580
66½	980	1220	1470	1720	1960	2210	2460	2720	2970	3220	3480	3730	3260	4500	5020	5550	6070	6600	7140	7670	8210	9310	10410	12680
72½	1160	1450	1740	2040	2330	2630	2920	3220	3520	3820	4120	4420	4730	5340	5950	6570	7140	7810	8440	9080	9710	11000	12300	14960
78½	1360	1700	2040	2390	2730	3080	3420	3770	4120	4470	4820	5180	5530	6240	6960	7680	8400	9130	9860	10600	11340	12840	14350	17440
84½	1570	1970	2360	2760	3160	3560	3960	4370	4770	5180	5580	5990	6400	7220	8040	8870	9710	10550	11390	12240	13090	14820	16560	20100
90½	1800	2260	2710	3170	3620	4080	4540	5000	5460	5930	6390	6860	7330	8260	9210	10160	11110	12070	13030	14000	14970	16940	18920	22950
96½	2050	2560	3080	3600	4120	4640	5160	5680	6210	6730	7260	7790	8320	9380	10450	11530	12610	13690	14780	15880	16980	19200	21440	25990

PLATE GIRDER STIFFENERS

A.I.S.C. SPECIFICATION AS REVISED - 1946

Tension: Net Section = 20000.

Compression: Plate Girder Stiffeners, Gross Section = 20000.

Shear: Webs of Plate Girders Gross Section = 13000.

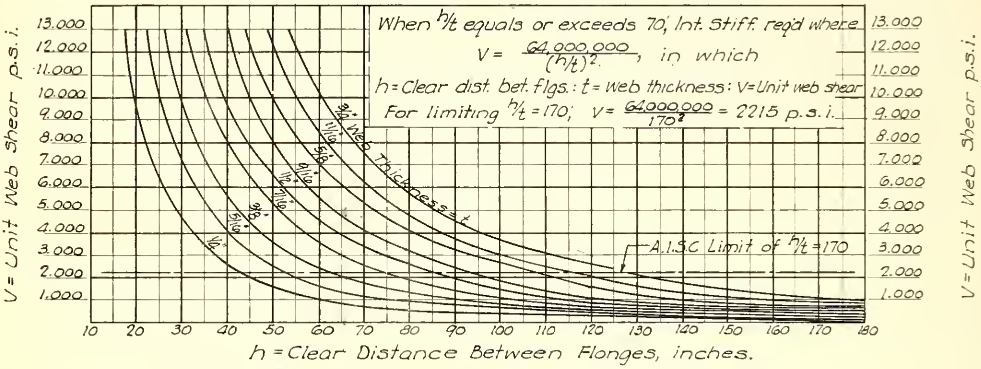
Bending: Tension, extreme fiber = 20000.

Compression: On Extreme Fiber:
when ld/bt does not exceed 600 = 20000.
when ld/bt exceeds 600 = $\frac{12{,}000{,}000}{ld/bt}$

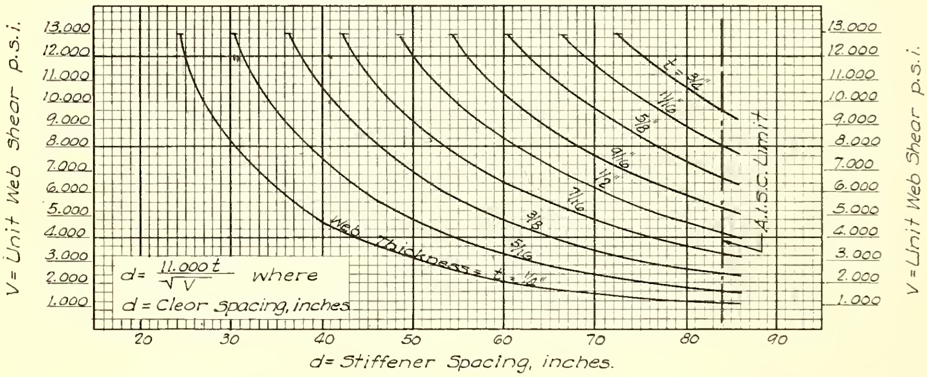
For bearing stiffeners, and for general design criteria, see Section 26, A.I.S.C. Specification, 1946.

For intermediate stiffeners: Chart No. 1 gives web thickness required for various clear depths: Chart No. 2 gives spacing of stiffeners required: and Chart No. 3 gives Moment of Inertia needed to resist web buckling.

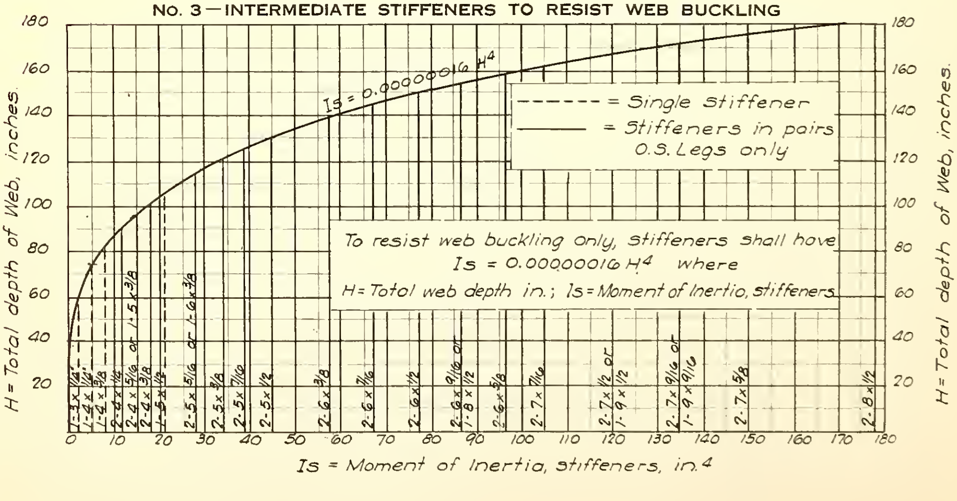
No. 1 — WEB THICKNESS FOR VARIOUS CLEAR DEPTHS



No. 2 — SPACING OF INTERMEDIATE STIFFENERS



No. 3 — INTERMEDIATE STIFFENERS TO RESIST WEB BUCKLING



EXPLANATION OF PLATE GIRDER TABLES

TYPICAL DESIGN

The tables for the design of Plate Girders consist of tabulated Moments of Inertia, both Gross and Net, for Web Plates, Cover Plates and Flange Angles; Chart No. 1, Web Thickness for Various Clear depths; Chart No. 2, Spacing of Intermediate Stiffeners; Chart No. 3, Intermediate Stiffeners to Resist Web Buckling.

Assume a girder of 60′-0″ span is to be designed to carry a total uniform load of 6,000# per lin. ft. The bending moment will be $(6{,}000 \times 60^2 \times 12) \div 8 = 32{,}400{,}000$″/#s. Assume a web plate 48″ deep and flange angles 8 × 6. The clear distance between flanges is $48\frac{1}{2} - 12 = 36\frac{1}{2}$.

Web Thickness, Stiffener Spacing and Size:

Charts No. 1, 2 and 3 are used. No. 1 gives unit shear values for webs without stiffeners. To increase unit shear values, stiffeners are required at spacing shown in Chart No. 2 and the size of stiffener is shown in No. 3. Several thicknesses of web will meet the requirements for stress, depending on whether stiffeners are used or not and dependent on their spacing. Tabulated below are several choices:

$$\text{Total } V = 6000 \times 60 \div 2 = 180{,}000\#$$

Web Thickness = T	Actual Unit Shear V = 180,000 ÷ 48 T	Allowable Unit Shear For Unstiffened Web V From Chart No. 1 H = 36½″	Stiffener Spacing to Make Allowable Value of Unit Shear Sufficient for Actual Value Chart No. 2
$\frac{5}{16}$″	12,000	4,700	31″
⅜″	10,000	6,750	41″
$\frac{7}{16}$″	8,600	9,200	None
½″	7,500	12,000	None

Any of the above web thicknesses can be used with the corresponding stiffener spacing with very little difference in economy so the $\frac{7}{16}$″ web is selected with no stiffeners.

Section: The section modulus required is $32{,}400{,}000 \div 18{,}000 = 1{,}800$. With assumed depth of 51″ out to out of covers, required moment of inertia is $(51 \div 2) \times 1{,}800 = 45{,}900$.

				The gross I of 18×1⅛ Pls. = 18×1,386 =	24,948
The 48×$\frac{7}{16}$ plate web (net)	3,674		45,900	Deduct 4 holes as	
Assume 4-8×6×⅞ flg. angles (net)	20,490	Then	24,164	tabulated	2,420
	24,164		21,736	by covers	22,528

The net moment of inertia of the section is: Web 3,674
Angles 20,490
Covs. 22,528 46,692

Cover Plate Lengths: With uniform load, the flange area of girders varies as the ordinates of a parabola and the theoretical length of cov. pls. will be: $L_1 = L\sqrt{a_1 \div A}$, $L_2 = L\sqrt{a_2 \div A}$, $L_3 = L\sqrt{a_3 \div A}$, etc.; where L=Length of girder; L_1, L_2, etc. =Length of cover, outer first; a_1, a_2, etc.=Total area of cover plates, from outer to inner; A=Total area of Flange. Add 12″ to 18″ to theoretical length of cover to take up the shear.

In the example, assume the 1⅛″ covers to be composed of 1⅝ and 1½ plates. Utilizing ⅛ of the web area as added to flange, the Net Flange area will be:

Outer plate $=60\sqrt{(8.12\div40.78)}$
$=26.7'$, say $28'$.

Inner plate extends full length.

2 Angles	8×6×⅞	22.96—3.08=19.88
1 Inner Cover	18×⅝	11.25—1.10=10.15
1 Outer Cover	18×½	9.00— .88= 8.12
⅛ Web	$48\times\frac{7}{16}$	2.63 = 2.63
		40.78□″

Rivets in Cover Plates:

$$s=\frac{n\times R\times d_1}{V}\times\frac{A}{A_c}$$

where s=Rivet spacing R=Rivet value. A_c=Net area first cov.
n=No. rivets, transverse line. V=Total shear.
d_1=Distance b. to b. angles A=Total flg. area, net.

In the example: $s=\dfrac{2\times5{,}960\times48.5}{180{,}000}\times\dfrac{40.78}{10.15}=12.9''$

Where more than one cover plate, reduce the calculated pitch by 15% for each cover over one.

Rivets in Flange Angles:

$p=aR\div V$ in which p=Rivet pitch; a=Dist. bet. rivet lines; R=Value one rivet; V=Total vertical shear in panel.

In the example: Shear Panel 1. $=180{,}000.$
Panel 2. $(180{,}000-(6{,}000\times3)=162{,}000$, etc.
Horizontal stress $=180{,}000\div43.5=4{,}130.$
$162{,}000\div43.5=3{,}730$, etc.

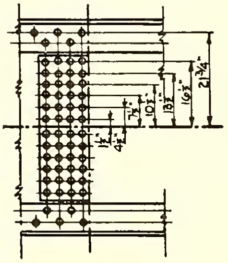
Rivet pitch, Panel 1. $9{,}840\div4{,}130=2.38$, say 2¼.
Panel 2. $9{,}840\div3{,}730=2.64$, say 2½.

If rivets are spaced on double gage lines, stagger for net section.

If ⅛ web is included in flange area the formula is $p=\dfrac{Rd_e}{V[A_F\div(A_F+\frac{1}{8}A_W)]}$, where d_e=Eff. depth; A_F=Net Flg. area; A_W=Area web.

Web Splices: Assume a web splice 20′ from one end girder. Rivets in splice to resist bending moment at 18,000# fiber stress, plus shear at point of splice.

Max. shear is $(6{,}000\times30)-(6{,}000\times20)=60{,}000$
Moment resisted by ⅛ web is $48\times2.63\times18{,}000=2{,}272{,}000''$/#s
Bearing of ¾″ rivet on $\frac{7}{16}$ plate, outer line = 9,840
Max. value outer rivet in splice $=9{,}840\times16.5\div21.75=7{,}470$
Max. shear per rivet $=60{,}000\div48=1{,}250$
Mom. resisted per rivet $=2{,}272{,}000\div312=7{,}280$
Max. combined stress, outer line $=\sqrt{7{,}280^2+1{,}250^2}=7{,}380$



Refer to Table of Squares, I of Rivets @ 3″ Spacing

$8\times1.5^2=18$
$8\times4.5^2=162$
$8\times7.5^2=450$
$8\times10.5^2=882$
$8\times13.5^2=1{,}458$
$8\times16.5^2=2{,}178$
$I=5{,}148$

$s=5{,}148\div16.5=312$

Thickness of Splice Plates. The moment of Inertia about neutral axis of splice plates should equal or exceed the moment of Inertia of web.

Thus, $(t)(36)^3=(\frac{7}{16})(48)^3$

and $t=\dfrac{(\frac{7}{16})(48)^3}{36^3}=1.035$

Each plate must be $1.035\div2=.518''$

General: Fillers would be used under stiffeners for girders less than 48″ deep; for deeper girders the stiffeners may be crimped except under concentrated loads or at supports. Maximum rivet pitch in stiffeners, 6″. Maximum pitch in line of stress of compression members composed of plates and shapes shall not exceed 16 times the thinnest outside plate or shape, nor 20 times the thinnest enclosed plate, with maximum of 12″, and at right angles to direction of stress the distance between rivets shall not exceed 30 times the thinnest plate or shape. Maximum distance from any edge shall be 8 times the thickness of plate.

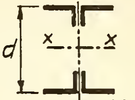
G = Gross Moment of Inertia (I).
W = Net I, 13/16" web holes out.
WF = Net I, 13/16" web and flange holes out.

PLATE GIRDERS

MOMENTS OF INERTIA OF FLANGE ANGLES

AXIS X-X

FOR UNEQUAL ANGLES, SHORT LEGS B. TO B.



3 x 2½
3½ x 2½
3 x 3

SIZE	THICKNESS	GROSS AREA 4 ANGLES	I	Distance Back to Back of Angles, "d", Inches																			
				8½	9½	10½	11½	12½	13½	14½	15½	16½	17½	18½	19½	20½	21½	22½	23½	24½	26½	28½	30½
3 x 2½	¼	5.24	G	70	90	115	140	165	195	230	265	305	345	390	435	485	535	590	645	705	835	970	1120
			W	65	80	100	120	145	170	200	230	265	300	335	375	415	460	505	555	605	710	830	950
			WF	50	60	75	95	115	145	155	180	205	235	265	295	325	360	395	435	475	560	650	750
	5/16	6.48	G	85	110	140	170	205	240	280	325	375	425	480	535	595	660	730	800	870	1030	1195	1380
			W	75	100	125	150	180	210	245	285	325	365	410	460	510	565	620	680	740	875	1015	1170
			WF	60	75	95	115	140	160	190	220	250	285	320	360	400	440	485	535	580	685	800	920
	⅜	7.68	G	100	130	160	200	240	285	335	385	440	500	565	630	705	780	855	940	1025	1210	1410	1630
			W	90	115	140	175	210	245	290	330	380	430	485	540	600	665	730	800	870	1025	1195	1375
			WF	65	85	110	135	160	190	225	255	295	335	375	420	465	515	570	625	680	805	935	1075
	7/16	8.84	G	110	140	180	220	265	315	370	430	490	560	630	710	790	875	965	1060	1160	1370	1595	1845
			W	95	125	155	190	230	270	315	365	420	475	535	600	670	740	815	895	975	1155	1345	1550
			WF	70	95	115	145	175	205	240	280	320	365	415	460	515	570	630	690	755	895	1040	1200
	½	10.00	G	130	165	210	255	310	365	430	495	570	645	730	815	910	1005	1110	1215	1330	1570	1830	2110
			W	115	145	180	220	265	315	370	425	485	550	620	690	770	850	935	1025	1120	1320	1540	1770
			WF	85	110	140	170	205	240	280	325	375	425	475	535	595	660	725	795	870	1025	1195	1375
	9/16	11.12	G	140	180	230	280	340	405	475	545	630	715	805	900	1005	1115	1225	1345	1470	1740	2025	2335
			W	125	160	200	245	295	345	405	465	535	605	685	765	850	940	1035	1135	1240	1460	1700	1960
			WF	95	120	150	185	225	265	310	355	410	465	525	585	655	725	800	875	955	1130	1315	1515
3½ x 2½	¼	5.76	G	80	100	125	155	185	220	255	295	340	385	435	485	540	595	655	720	785	925	1075	1240
			W	70	90	115	140	165	195	225	260	300	335	380	425	470	520	570	625	680	800	930	1070
			WF	55	75	90	110	130	155	185	210	240	270	305	340	380	420	460	505	550	650	755	870
	5/16	7.12	G	95	125	155	190	230	270	315	365	415	470	530	595	660	730	805	885	965	1135	1325	1525
			W	90	110	140	170	200	240	275	320	365	415	465	520	575	635	700	765	835	980	1140	1315
			WF	70	90	110	135	160	190	220	255	290	330	375	415	465	515	565	620	675	795	925	1065
	⅜	8.44	G	115	145	180	225	270	315	370	430	490	555	625	700	780	865	950	1045	1140	1345	1565	1800
			W	100	130	160	200	235	280	325	375	430	485	545	610	680	750	825	900	985	1160	1345	1550
			WF	80	105	130	155	190	220	260	300	345	390	440	490	545	605	660	725	790	935	1085	1250
	7/16	9.72	G	130	165	210	255	305	365	425	490	560	640	720	805	895	990	1090	1195	1305	1540	1795	2070
			W	115	150	185	225	270	320	370	430	490	555	625	700	775	855	940	1030	1125	1325	1540	1775
			WF	90	120	145	180	215	255	295	340	390	445	500	560	620	685	755	825	905	1065	1240	1425
	½	11.00	G	145	185	235	285	345	410	475	550	630	720	810	905	1010	1115	1230	1350	1475	1740	2025	2335
			W	130	165	205	250	300	355	415	480	550	625	700	785	870	965	1060	1160	1265	1490	1735	1995
			WF	100	130	165	200	240	285	330	385	435	495	560	625	695	770	845	930	1015	1195	1390	1605
	9/16	12.24	G	160	205	255	315	380	450	525	610	700	795	895	1000	1115	1235	1360	1490	1630	1925	2245	2585
			W	140	180	225	275	330	395	460	530	605	685	775	865	960	1060	1170	1280	1395	1645	1915	2210
			WF	110	145	175	220	260	310	360	420	480	545	615	685	765	845	930	1020	1115	1315	1535	1765
	⅝	13.44	G	170	220	280	340	415	490	575	665	760	865	975	1095	1220	1350	1490	1635	1785	2105	2455	2830
			W	155	195	245	300	360	425	500	575	660	750	840	940	1045	1160	1275	1400	1525	1800	2095	2410
			WF	120	155	195	235	285	335	395	455	520	590	665	745	830	920	1015	1110	1215	1430	1670	1925
	11/16	14.60	G	185	240	300	370	445	530	620	720	825	935	1055	1185	1320	1460	1610	1765	1930	2280	2660	3070
			W	165	210	265	325	390	460	535	620	710	805	910	1015	1130	1250	1375	1510	1645	1940	2260	2605
			WF	125	165	205	255	305	360	420	490	560	635	715	800	895	990	1090	1195	1305	1540	1795	2070
3 x 3	¼	5.76	G	70	95	115	145	175	205	240	280	320	365	410	460	515	570	630	690	755	890	1040	1200
			W	65	85	105	130	155	185	215	250	285	320	365	405	450	500	550	600	660	775	905	1040
			WF	50	65	85	100	125	145	170	195	225	255	290	325	360	400	440	485	530	625	730	840
	5/16	7.12	G	85	115	145	175	210	250	295	345	395	450	505	565	630	700	775	850	930	1095	1280	1480
			W	80	105	130	160	190	225	265	305	350	395	445	495	555	610	675	740	805	950	1110	1280
			WF	60	80	100	125	150	175	210	240	275	315	355	395	440	490	540	595	645	765	895	1030
	⅜	8.44	G	100	135	165	205	250	295	350	405	465	530	595	670	745	830	915	1005	1095	1295	1515	1750
			W	95	120	150	185	225	265	310	355	410	465	525	585	650	720	795	870	950	1125	1310	1510
			WF	70	95	115	145	175	205	245	280	325	370	415	465	520	575	635	695	760	900	1050	1210
	7/16	9.72	G	115	150	190	235	285	340	400	465	530	605	685	770	855	960	1045	1150	1260	1490	1740	2010
			W	105	135	170	210	255	300	355	410	465	530	600	670	745	825	910	995	1090	1285	1500	1730
			WF	80	105	135	165	200	235	275	320	370	420	475	530	590	655	725	795	865	1025	1200	1385
	½	11.00	G	130	170	215	265	320	380	450	520	600	680	770	865	965	1070	1180	1295	1420	1680	1960	2265
			W	120	155	195	235	285	340	395	460	525	595	670	755	840	930	1020	1120	1225	1445	1685	1945
			WF	90	120	150	185	220	265	310	360	410	470	530	595	665	735	810	890	975	1150	1345	1550
	9/16	12.24	G	145	185	235	290	355	420	495	575	660	755	855	955	1070	1185	1310	1435	1575	1860	2175	2515
			W	130	170	210	260	315	375	435	505	580	660	740	830	925	1025	1130	1240	1355	1600	1865	2155
			WF	100	130	165	200	245	290	340	395	455	515	585	655	725	810	895	980	1075	1270	1485	1715
	⅝	13.44	G	155	200	255	315	385	460	540	625	720	820	930	1045	1165	1295	1430	1570	1715	2035	2375	2745
			W	140	180	230	280	340	405	475	545	630	715	805	905	1005	1115	1230	1350	1475	1745	2035	2350
			WF	105	140	175	215	265	310	370	425	490	560	630	710	790	880	970	1065	1165	1380	1610	1860

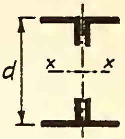
G = Gross Moment of Inertia (I).
W = Net I, 13/16" web holes out.
WF = Net I, 13/16" web and flange holes out.

PLATE GIRDERS

MOMENTS OF INERTIA OF FLANGE ANGLES

AXIS X-X

FOR UNEQUAL ANGLES, SHORT LEGS B. TO B.



4 x 3
4 x 4

SIZE	THICKNESS	GROSS AREA 4 ANGLES	I	Distance Back to Back of Angles, "d", Inches																				
				12½	13½	14½	15½	16½	18½	20½	22½	24½	26½	28½	30½	32½	34½	36½	38½	40½	42½	44½	46½	48½
4 x 3	¼	6.76	G	210	250	290	340	385	495	615	755	900	1065	1240	1430	1630	1850	2080	2320	2580	2850	3130	3430	3740
			W	195	230	265	305	350	445	555	675	805	950	1105	1270	1450	1640	1840	2050	2280	2520	2770	3030	3300
			WF	160	190	220	255	290	375	465	565	675	795	930	1070	1220	1380	1550	1730	1930	2130	2340	2560	2790
	5/16	8.36	G	260	305	360	415	475	610	760	925	1110	1310	1530	1760	2010	2280	2560	2870	3180	3520	3870	4240	4620
			W	235	280	325	375	430	545	680	830	990	1165	1355	1565	1780	2020	2270	2530	2810	3100	3410	3730	4070
			WF	195	230	270	315	360	455	570	695	830	980	1140	1315	1500	1700	1910	2130	2370	2610	2870	3150	3430
	⅜	9.92	G	305	360	425	490	560	720	895	1095	1315	1550	1810	2085	2380	2700	3040	3390	3770	4160	4580	5020	5470
			W	280	330	385	445	505	645	800	975	1170	1375	1600	1845	2110	2380	2680	2990	3320	3670	4030	4410	4810
			WF	230	270	320	370	420	535	670	815	975	1150	1340	1550	1770	2000	2250	2510	2790	3080	3390	3710	4050
	7/16	11.48	G	350	415	485	565	645	830	1035	1260	1515	1790	2085	2405	2750	3120	3500	3920	4350	4810	5290	5800	6320
			W	320	375	440	510	580	740	925	1125	1345	1585	1845	2125	2430	2750	3090	3450	3830	4230	4650	5090	5550
			WF	265	310	365	420	480	615	770	940	1125	1325	1545	1780	2030	2300	2590	2890	3210	3550	3900	4280	4660
	½	13.00	G	390	465	545	630	725	930	1165	1420	1705	2015	2350	2715	3100	3520	3960	4420	4910	5430	5970	6540	7140
			W	355	420	495	570	650	835	1035	1265	1510	1785	2080	2395	2730	3100	3480	3890	4310	4770	5240	5740	6250
			WF	295	345	405	470	540	690	860	1050	1260	1490	1735	2000	2290	2590	2910	3250	3610	3990	4390	4810	5250
	9/16	14.48	G	435	515	605	700	805	1030	1290	1575	1890	2235	2610	3015	3450	3910	4400	4910	5460	6040	6640	7280	7940
			W	395	465	545	630	720	920	1150	1400	1675	1975	2305	2655	3030	3430	3860	4310	4790	5290	5820	6370	6940
			WF	325	385	450	520	595	765	950	1160	1395	1645	1920	2215	2530	2870	3220	3600	4000	4420	4870	5330	5810
	⅝	15.92	G	470	560	660	765	880	1130	1410	1725	2075	2450	2860	3305	3780	4280	4820	5390	5990	6620	7290	7990	8710
			W	430	505	595	685	785	1005	1255	1530	1830	2160	2520	2905	3320	3760	4220	4720	5240	5790	6370	6980	7610
			WF	350	415	490	565	650	830	1040	1270	1520	1795	2095	2415	2760	3130	3520	3940	4370	4830	5320	5820	6350
	11/16	17.36	G	510	610	715	830	955	1225	1535	1875	2255	2665	3110	3590	4110	4660	5240	5860	6520	7210	7930	8690	9490
			W	465	550	640	740	850	1090	1360	1660	1990	2345	2735	3155	3600	4080	4590	5130	5700	6290	6920	7580	8270
			WF	380	450	525	610	700	900	1125	1375	1645	1945	2270	2620	2990	3390	3820	4270	4740	5240	5770	6320	6890
	¾	18.76	G	545	650	765	890	1025	1315	1645	2015	2420	2865	3345	3865	4420	5020	5650	6320	7020	7770	8550	9370	10220
			W	495	585	685	795	910	1165	1455	1780	2130	2520	2935	3385	3870	4390	4930	5510	6130	6770	7450	8150	8900
			WF	400	480	560	650	750	960	1200	1470	1760	2085	2430	2805	3210	3640	4090	4580	5090	5630	6190	6780	7400
4 x 4	¼	7.76	G	220	260	305	355	410	530	665	815	980	1160	1355	1570	1800	2040	2300	2570	2860	3170	3490	3820	4170
			W	205	245	285	330	380	490	610	745	895	1060	1235	1425	1630	1850	2080	2330	2590	2860	3150	3450	3760
			WF	175	205	240	280	325	415	520	640	765	905	1060	1225	1400	1590	1790	2010	2310	2470	2720	2980	3250
	5/16	9.60	G	265	320	375	435	505	650	825	1010	1205	1425	1670	1930	2210	2510	2830	3170	3530	3910	4300	4720	5150
			W	250	300	350	405	465	600	760	925	1100	1300	1520	1755	2010	2280	2560	2860	3180	3520	3870	4250	4630
			WF	210	250	295	345	395	510	650	790	940	1115	1300	1505	1720	1960	2200	2460	2740	3030	3340	3660	4000
	⅜	11.44	G	315	375	445	515	595	770	965	1185	1430	1695	1985	2295	2630	2990	3370	3770	4200	4640	5120	5610	6130
			W	300	355	415	480	555	710	890	1085	1305	1545	1805	2080	2380	2700	3040	3400	3780	4180	4600	5050	5510
			WF	250	295	350	405	470	600	755	925	1115	1320	1545	1785	2040	2320	2610	2920	3250	3600	3960	4350	4750
	7/16	13.24	G	365	435	510	595	685	885	1115	1370	1650	1955	2290	2650	3040	3450	3890	4350	4850	5360	5910	6480	7080
			W	340	405	475	555	635	815	1020	1250	1500	1780	2080	2400	2750	3120	3510	3920	4360	4830	5310	5820	6360
			WF	285	340	400	465	535	690	870	1065	1280	1520	1775	2055	2350	2670	3010	3370	3750	4150	4570	5010	5470
	½	15.00	G	410	490	575	670	770	1000	1255	1545	1860	2210	2585	2990	3430	3900	4390	4920	5480	6060	6680	7330	8010
			W	385	455	535	620	715	920	1150	1410	1695	2005	2345	2710	3100	3520	3960	4430	4930	5450	6000	6580	7180
			WF	320	380	450	525	600	775	975	1195	1440	1710	2000	2315	2650	3010	3390	3800	4230	4680	5150	5650	6170
	9/16	16.72	G	450	540	635	740	855	1105	1390	1710	2060	2450	2870	3320	3810	4330	4880	5470	6090	6740	7430	8150	8900
			W	420	500	590	685	790	1015	1275	1560	1875	2220	2595	3000	3440	3900	4390	4910	5470	6050	6660	7300	7970
			WF	350	420	495	575	665	855	1075	1320	1595	1890	2210	2560	2930	3330	3760	4210	4680	5180	5710	6260	6840
	⅝	18.44	G	490	590	695	810	935	1215	1525	1880	2265	2690	3155	3650	4190	4760	5370	6020	6700	7420	8180	8970	9800
			W	460	550	645	750	865	1115	1395	1710	2060	2440	2850	3295	3770	4280	4830	5400	6010	6650	7320	8030	8760
			WF	385	455	540	630	725	940	1180	1450	1745	2075	2425	2810	3220	3660	4120	4620	5140	5690	6270	6880	7510
	11/16	20.12	G	530	640	755	880	1015	1315	1660	2040	2465	2925	3430	3970	4560	5180	5840	6550	7290	8080	8900	9770	10670
			W	500	595	700	815	935	1205	1515	1855	2235	2650	3095	3580	4100	4660	5250	5870	6530	7230	7960	8730	9530
			WF	415	495	585	680	785	1015	1275	1570	1895	2245	2630	3045	3490	3970	4470	5010	5580	6180	6810	7470	8160
	¾	21.76	G	570	685	810	945	1090	1415	1785	2200	2655	3155	3695	4285	4910	5590	6300	7070	7870	8720	9610	10540	11520
			W	535	635	750	875	1005	1295	1625	1995	2405	2850	3335	3855	4420	5020	5650	6330	7040	7790	8590	9410	10280
			WF	440	530	625	730	840	1090	1370	1685	2035	2415	2830	3275	3760	4270	4810	5390	6010	6650	7330	8040	8780
	13/16	23.36	G	605	730	860	1005	1165	1510	1905	2350	2840	3375	3955	4585	5260	5980	6750	7570	8430	9340	10300	11300	12350
			W	565	675	800	930	1070	1380	1735	2130	2570	3045	3565	4120	4720	5360	6050	6770	7530	8340	9190	10070	11000
			WF	470	565	665	775	895	1160	1460	1795	2170	2575	3020	3495	4010	4560	5140	5760	6410	7100	7830	8590	9380

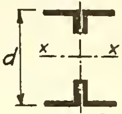
G = Gross Moment of Inertia (I).
W = Net I, 13/16″ web holes out.
WF = Net I, 13/16″ web and flange holes out.

PLATE GIRDERS

MOMENTS OF INERTIA OF FLANGE ANGLES

AXIS X-X

FOR UNEQUAL ANGLES, SHORT LEGS B. TO B.



5 x 3
5 x 3½

SIZE	THICKNESS	GROSS AREA 4 ANGLES	I	Distance Back to Back of Angles, "d", Inches																				
				18½	20½	22½	24½	26½	28½	30½	32½	34½	36½	38½	40½	42½	44½	46½	48½	54½	60½	66½	72½	78½
5 x 3	5/16	9.60	G	710	885	1080	1290	1525	1775	2045	2330	2640	2970	3320	3680	4070	4470	4900	5340	6780	8400	10190	12150	14290
			W	650	805	980	1170	1380	1605	1845	2100	2380	2670	2980	3310	3650	4010	4390	4790	6070	7510	9110	10850	12750
			WF	560	695	845	1010	1190	1385	1595	1820	2060	2320	2580	2870	3170	3480	3810	4150	5270	6520	7910	9430	11080
	3/8	11.44	G	845	1050	1280	1535	1810	2110	2430	2770	3140	3530	3950	4380	4840	5320	5830	6350	8070	10000	12130	14470	17010
			W	770	955	1165	1390	1635	1905	2190	2500	2830	3180	3540	3930	4340	4770	5220	5690	7220	8930	10830	12900	15160
			WF	665	825	1005	1200	1410	1645	1895	2160	2450	2750	3070	3400	3760	4130	4520	4930	6260	7750	9390	11200	13160
	7/16	13.24	G	970	1210	1475	1765	2085	2430	2800	3200	3600	4070	4550	5050	5580	6140	6720	7330	9320	11550	14010	16710	19650
			W	885	1100	1335	1595	1880	2190	2520	2880	3260	3660	4080	4530	5000	5500	6020	6560	8330	10300	12490	14890	17500
			WF	760	945	1150	1375	1620	1890	2175	2480	2810	3160	3530	3920	4330	4750	5200	5680	7210	8920	10820	12900	15170
	½	15.00	G	1095	1365	1665	1995	2355	2745	3165	3600	4090	4600	5140	5710	6310	6940	7600	8290	10540	13060	15850	18910	22240
			W	995	1240	1505	1800	2125	2470	2845	3250	3670	4130	4610	5120	5650	6210	6800	7410	9410	11640	14120	16830	19780
			WF	855	1065	1295	1550	1825	2130	2450	2800	3170	3560	3980	4420	4880	5360	5870	6400	8130	10070	12210	14560	17120
	9/16	16.72	G	1215	1515	1850	2215	2615	3050	3515	4020	4550	5120	5720	6360	7020	7730	8460	9230	11740	14540	17650	21060	24770
			W	1105	1370	1670	2000	2355	2740	3160	3600	4080	4580	5120	5680	6280	6900	7550	8230	10460	12940	15700	18720	22000
			WF	945	1175	1435	1715	2025	2355	2715	3100	3510	3950	4410	4900	5410	5950	6510	7100	9020	11180	13560	16170	19010
	5/8	18.44	G	1330	1660	2025	2430	2870	3350	3865	4410	5000	5630	6290	6990	7720	8500	9310	10150	12910	16010	19430	23190	27270
			W	1205	1500	1830	2190	2580	3005	3465	3950	4480	5030	5620	6240	6890	7580	8300	9050	11490	14230	17260	20580	24200
			WF	1030	1285	1565	1875	2215	2580	2975	3400	3850	4330	4830	5370	5930	6530	7140	7790	9900	12270	14890	17760	20880
	11/16	20.12	G	1445	1800	2200	2640	3120	3640	4205	4800	5440	6130	6850	7610	8410	9250	10140	11060	14070	17440	21170	25270	29730
			W	1310	1630	1985	2375	2805	3265	3765	4300	4870	5470	6110	6790	7500	8240	9020	9840	12500	15490	18790	22410	26340
			WF	1115	1390	1700	2035	2405	2800	3230	3690	4180	4700	5250	5830	6440	7090	7760	8470	10760	13330	16180	19300	22700
	3/4	21.76	G	1555	1940	2370	2845	3365	3925	4530	5180	5870	6610	7390	8210	9080	9990	10940	11940	15190	18840	22870	27300	32120
			W	1405	1750	2135	2560	3020	3515	4055	4630	5240	5900	6590	7310	8080	8890	9730	10610	13480	16700	20270	24170	28430
			WF	1200	1495	1825	2190	2585	3010	3475	3970	4500	5060	5650	6280	6940	7630	8360	9110	11590	14360	17430	20800	24460
	13/16	23.36	G	1660	2075	2535	3045	3600	4205	4855	5550	6290	7080	7920	8800	9730	10700	11730	12800	16280	20190	24520	29270	34440
			W	1500	1870	2280	2730	3225	3760	4335	4950	5610	6310	7040	7830	8650	9510	10410	11360	14440	17880	21700	25890	30440
			WF	1275	1595	1945	2335	2755	3215	3710	4240	4800	5400	6030	6710	7410	8150	8930	9740	12390	15350	18630	22230	26150
5 x 3½	5/16	10.24	G	735	920	1120	1345	1590	1850	2135	2440	2770	3120	3480	3870	4280	4710	5150	5620	7150	8870	10770	12850	15120
			W	680	845	1025	1230	1450	1690	1945	2220	2510	2830	3160	3510	3870	4260	4660	5080	6460	8000	9700	11570	13600
			WF	590	735	890	1070	1260	1470	1695	1940	2190	2470	2760	3060	3390	3720	4080	4450	5650	7000	8500	10140	11930
	3/8	12.20	G	870	1090	1330	1595	1885	2200	2540	2900	3290	3700	4140	4600	5090	5600	6130	6690	8510	10550	12810	15290	17990
			W	805	1000	1220	1455	1720	2005	2310	2640	2990	3360	3750	4160	4600	5060	5540	6040	7670	9500	11530	13750	16170
			WF	695	865	1055	1265	1495	1745	2010	2300	2600	2930	3270	3640	4020	4420	4840	5280	6710	8320	10100	12050	14170
	7/16	14.12	G	1005	1255	1535	1840	2175	2540	2930	3350	3800	4280	4780	5310	5870	6460	7080	7730	9830	12190	14810	17680	20800
			W	925	1150	1400	1680	1980	2310	2660	3040	3440	3870	4320	4800	5310	5840	6390	6970	8860	10970	13310	15880	18680
			WF	800	995	1215	1455	1720	2010	2315	2650	3000	3370	3770	4190	4630	5090	5580	6080	7740	9590	11640	13900	16340
	½	16.00	G	1130	1410	1725	2075	2455	2865	3305	3780	4290	4830	5400	6000	6640	7300	8000	8730	11120	13790	16750	20000	23540
			W	1035	1295	1575	1890	2230	2600	3000	3430	3880	4370	4880	5420	5990	6590	7210	7870	10000	12390	15040	17950	21110
			WF	895	1120	1365	1640	1935	2260	2605	2980	3380	3800	4250	4720	5220	5740	6290	6860	8730	10820	13140	15680	18450
	9/16	17.88	G	1255	1570	1920	2310	2730	3190	3685	4210	4780	5380	6020	6690	7400	8150	8930	9740	12400	15390	18700	22320	26270
			W	1155	1435	1755	2100	2485	2895	3340	3810	4320	4860	5430	6040	6670	7340	8040	8770	11150	13820	16770	20010	23540
			WF	995	1240	1585	1820	2150	2510	2895	3310	3760	4230	4730	5250	5800	6390	7000	7640	9720	12050	14630	17470	20550
	5/8	19.68	G	1375	1720	2105	2530	2995	3500	4045	4630	5250	5910	6610	7350	8130	8950	9810	10700	13630	16910	20550	24540	28890
			W	1260	1570	1920	2300	2720	3175	3660	4180	4740	5330	5960	6620	7320	8050	8820	9620	12240	15170	18420	21980	25850
			WF	1085	1355	1660	1990	2355	2750	3170	3630	4110	4630	5170	5750	6360	7000	7670	8370	10650	13210	16040	19150	22540
	11/16	21.48	G	1495	1870	2290	2755	3260	3810	4400	5040	5710	6440	7200	8010	8860	9750	10680	11660	14860	18440	22400	26760	31500
			W	1365	1705	2085	2500	2955	3450	3980	4550	5150	5800	6480	7200	7960	8760	9600	10470	13320	16520	20050	23930	28160
			WF	1175	1470	1800	2160	2555	2985	3445	3940	4470	5030	5620	6250	6910	7610	8330	9100	11580	14360	17450	20830	24520
	3/4	23.24	G	1605	2010	2465	2965	3510	4100	4740	5430	6160	6940	7760	8630	9550	10520	11530	12590	16040	19910	24190	28900	34020
			W	1465	1830	2240	2690	3180	3710	4280	4890	5550	6250	6980	7760	8580	9440	10340	11290	14360	17810	21630	25820	30380
			WF	1260	1575	1930	2320	2745	3205	3700	4230	4800	5410	6050	6720	7440	8190	8970	9790	12470	15470	18790	22440	26420
	13/16	25.00	G	1715	2155	2640	3175	3765	4400	5085	5820	6610	7450	8330	9270	10260	11290	12380	13520	17220	21380	25990	31050	36560
			W	1570	1960	2395	2880	3405	3975	4585	5250	5950	6700	7490	8320	9200	10130	11090	12110	15410	19120	23220	27720	32620
			WF	1345	1685	2065	2480	2935	3430	3960	4530	5140	5790	6480	7200	7970	8770	9610	10490	13360	16580	20150	24060	28330
	7/8	26.68	G	1825	2285	2805	3380	4005	4680	5400	6200	7040	7930	8870	9870	10920	12030	13190	14400	18350	22790	27710	33100	38980
			W	1660	2075	2545	3055	3615	4220	4865	5580	6320	7120	7960	8850	9790	10770	11800	12880	16400	20350	24710	29510	34730
			WF	1425	1780	2185	2630	3110	3635	4190	4810	5460	6150	6880	7650	8460	9310	10210	11150	14200	17620	21420	25580	30120

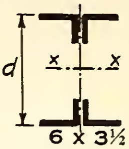
G = Gross Moment of Inertia (I).
W = Net I, 1⅛" web holes out.
WF = Net I, 1⅛" web and flange holes out.

PLATE GIRDERS

MOMENTS OF INERTIA OF FLANGE ANGLES

AXIS X-X

FOR UNEQUAL ANGLES, SHORT LEGS B. TO B.



6 x 3½
6 x 4

SIZE	THICKNESS	GROSS AREA 4 ANGLES	I	Distance Back to Back of Angles, "d", Inches																		
				24½	26½	28½	30½	32½	34½	36½	38½	40½	42½	44½	46½	48½	54½	60½	66½	72½	78½	84½
6 x 3½	5/16	11.48	G	1530	1805	2100	2420	2770	3130	3520	3940	4370	4830	5310	5820	6350	8070	10000	12130	14470	17020	19770
			W	1415	1665	1935	2230	2550	2880	3240	3610	4010	4430	4870	5330	5810	7370	9120	11060	13190	15500	18000
			WF	1255	1475	1720	1980	2260	2560	2880	3210	3570	3940	4330	4740	5170	6570	8130	9860	11760	13830	16060
	3/8	13.68	G	1810	2135	2490	2875	3280	3720	4180	4680	5190	5740	6310	6910	7540	9590	11890	14430	17220	20250	23530
			W	1670	1970	2295	2645	3020	3420	3840	4280	4760	5250	5780	6320	6890	8750	10840	13150	15680	18430	21400
			WF	1480	1745	2035	2345	2680	3030	3410	3810	4230	4670	5140	5620	6130	7790	9650	11710	13970	16420	19080
	7/16	15.88	G	2095	2475	2885	3325	3800	4310	4850	5420	6020	6650	7320	8010	8740	11120	13780	16730	19960	23480	27290
			W	1935	2280	2655	3055	3490	3950	4440	4960	5510	6080	6690	7320	7980	10140	12560	15230	18160	21360	24810
			WF	1710	2020	2355	2710	3100	3510	3940	4400	4890	5410	5940	6510	7100	9020	11170	13560	16180	19020	22100
	1/2	18.00	G	2365	2795	3260	3760	4300	4870	5480	6120	6810	7520	8280	9070	9890	12580	15600	18940	22600	26590	30900
			W	2180	2575	2995	3455	3940	4460	5020	5600	6220	6880	7560	8280	9020	11470	14200	17230	20550	24160	28060
			WF	1930	2275	2655	3060	3490	3960	4450	4970	5520	6100	6710	7350	8020	10190	12630	15320	18280	21500	24980
	9/16	20.12	G	2630	3105	3625	4185	4780	5420	6100	6820	7580	8380	9220	10110	11030	14030	17400	21130	25220	29670	34490
			W	2420	2860	3330	3840	4380	4970	5580	6240	6930	7650	8420	9220	10050	12780	15830	19200	22910	26940	31300
			WF	2140	2525	2945	3400	3880	4400	4950	5530	6140	6790	7470	8180	8920	11340	14060	17060	20360	23950	27830
	5/8	22.20	G	2890	3415	3990	4605	5270	5970	6720	7510	8350	9230	10160	11130	12150	15460	19170	23280	27790	32700	38020
			W	2660	3140	3660	4220	4820	5460	6140	6860	7620	8420	9260	10140	11060	14060	17420	21150	25230	29670	34470
			WF	2350	2775	3235	3735	4270	4830	5440	6080	6750	7460	8210	8990	9810	12480	15460	18770	22400	26350	30620
	11/16	24.24	G	3145	3720	4340	5015	5730	6500	7320	8180	9100	10060	11070	12130	13240	16850	20900	25390	30310	35670	41470
			W	2890	3415	3980	4590	5240	5940	6680	7470	8300	9170	10080	11040	12050	15320	18980	23040	27490	32330	37570
			WF	2550	3015	3515	4055	4640	5250	5910	6610	7340	8120	8930	9780	10670	13580	16830	20430	24390	28690	33340
	3/4	26.24	G	3385	4005	4680	5405	6130	7010	7900	8830	9820	10860	11950	13100	14290	18200	22580	27430	32760	38560	44820
			W	3110	3675	4285	4845	5650	6400	7200	8050	8940	9890	10880	11910	12990	16530	20490	24870	29680	34910	40570
			WF	2740	3240	3780	4360	4990	5650	6360	7110	7910	8740	9620	10540	11500	14630	18140	22030	26300	30950	35970
	13/16	28.24	G	3630	4295	5020	5800	6640	7530	8480	9480	10540	11660	12840	14070	15360	19560	24270	29490	35210	41450	48190
			W	3330	3935	4595	5300	6060	6870	7730	8640	9600	10610	11670	12780	13950	17750	22000	26710	31880	37500	43590
			WF	2935	3470	4050	4675	5350	6060	6820	7630	8480	9370	10310	11300	12330	15700	19470	23640	28220	33210	38610
	7/8	30.20	G	3870	4580	5350	6185	7080	8030	9040	10120	11250	12450	13700	15020	16390	20880	25920	31500	37620	44280	51490
			W	3545	4190	4890	5645	6460	7320	8240	9210	10230	11310	12450	13630	14880	18930	23470	28500	34020	40030	46530
			WF	3120	3690	4310	4975	5690	6450	7260	8120	9030	9990	10990	12040	13140	16730	20750	25210	30090	35420	41170
	15/16	32.12	G	4100	4855	5675	6560	7510	8520	9600	10740	11930	13210	14550	15940	17410	22180	27530	33460	39960	47050	54710
			W	3755	4440	5185	5985	6840	7760	8730	9760	10840	12000	13200	14460	15780	20090	24910	30250	36110	42490	49390
			WF	3300	3905	4560	5265	6030	6830	7690	8610	9560	10580	11640	12760	13930	17730	22000	26730	31910	37560	43670
	1	34.00	G	4325	5125	5990	6925	7930	9000	10130	11340	12620	13960	15370	16850	18390	23440	29100	35370	42250	49750	57850
			W	3955	4680	5465	6310	7220	8180	9210	10300	11450	12660	13930	15270	16660	21210	26310	31950	38150	44890	52180
			WF	3475	4110	4800	5550	6350	7200	8110	9070	10080	11150	12280	13460	14690	18700	23210	28200	33670	39640	46080
6 x 4	3/8	14.44	G	1865	2210	2580	2975	3400	3860	4350	4860	5400	5980	6580	7210	7870	10020	12430	15090	18020	21210	24660
			W	1740	2055	2395	2765	3160	3580	4020	4490	4990	5520	6070	6640	7250	9210	11410	13850	16530	19440	22590
			WF	1550	1830	2135	2465	2820	3190	3590	4020	4460	4930	5430	5940	6490	8250	10230	12420	14820	17440	20270
	7/16	16.72	G	2155	2550	2975	3435	3930	4460	5020	5620	6240	6910	7600	8330	9090	11580	14370	17460	20850	24540	28530
			W	2010	2370	2765	3190	3640	4130	4640	5190	5760	6370	7000	7670	8370	10640	13190	16010	19100	22470	26110
			WF	1785	2110	2465	2840	3250	3680	4140	4630	5150	5690	6260	6860	7480	9520	11810	14340	17110	20140	23400
	1/2	19.00	G	2435	2880	3365	3890	4450	5050	5690	6360	7070	7820	8610	9440	10310	13130	16290	19800	23650	27840	32370
			W	2270	2680	3125	3605	4120	4670	5250	5870	6520	7210	7930	8690	9480	12060	14940	18140	21650	25480	29610
			WF	2015	2385	2780	3210	3670	4160	4680	5240	5820	6440	7080	7760	8470	10780	13370	16240	19390	22810	26520
	9/16	21.24	G	2710	3210	3750	4335	4960	5630	6340	7090	7890	8730	9610	10530	11500	14650	18190	22110	26410	31090	36150
			W	2525	2980	3480	4015	4590	5200	5850	6540	7270	8040	8840	9690	10570	13450	16670	20240	24160	28430	33040
			WF	2240	2650	3095	3575	4090	4630	5220	5830	6490	7170	7890	8650	9440	12010	14900	18100	21620	25440	29570
	5/8	23.44	G	2980	3530	4125	4770	5460	6200	6980	7810	8690	9610	10590	11600	12670	16150	20040	24360	29110	34270	39860
			W	2775	3275	3825	4415	5050	5720	6440	7200	8000	8840	9730	10660	11630	14810	18360	22300	26610	31320	36400
			WF	2460	2910	3400	3925	4490	5090	5730	6410	7130	7890	8680	9510	10380	13220	16400	19920	23790	28000	32550
	11/16	25.60	G	3240	3835	4485	5185	5940	6740	7600	8500	9460	10470	11530	12640	13800	17590	21850	26560	31730	37370	43470
			W	3010	3560	4155	4795	5480	6220	7000	7830	8700	9620	10590	11600	12660	16120	19990	24280	28990	34120	39660
			WF	2670	3160	3690	4260	4880	5530	6230	6970	7750	8570	9430	10340	11290	14380	17840	21680	25890	30480	35440
	3/4	27.76	G	3500	4145	4850	5610	6420	7290	8220	9200	10240	11330	12480	13680	14940	19050	23660	28760	34370	40480	47090
			W	3250	3845	4490	5180	5930	6720	7570	8460	9410	10410	11450	12550	13700	17440	21630	26280	31380	36940	42940
			WF	2880	3410	3985	4600	5270	5970	6730	7530	8370	9260	10200	11180	12200	15540	19290	23450	28000	32970	38340
	13/16	29.88	G	3750	4450	5205	6020	6900	7830	8830	9880	11000	12170	13400	14700	16050	20470	25430	30920	36960	43530	50630
			W	3480	4120	4810	5560	6360	7210	8120	9080	10100	11170	12290	13470	14710	18730	23240	28230	33720	39690	46140
			WF	3085	3650	4265	4930	5640	6400	7220	8070	8980	9930	10940	11990	13090	16680	20700	25170	30060	35390	41160
	7/8	31.92	G	3995	4735	5540	6410	7350	8340	9410	10530	11720	12970	14290	15670	17120	21830	27130	32990	39430	46450	54040
			W	3700	4380	5120	5915	6770	7680	8650	9670	10760	11900	13100	14350	15670	19960	24770	30100	35940	42310	49200
			WF	3275	3880	4535	5240	6000	6810	7680	8590	9550	10570	11640	12760	13930	17760	22050	26800	32020	37700	43840
	15/16	34.00	G	4240	5025	5885	6810	7800	8870	10000	11190	12460	13790	15190	16660	18200	23220	28850	35100	41950	49420	57500
			W	3925	4650	5430	6275	7180	8150	9180	10270	11420	12640	13910	15250	16650	21210	26330	31990	38220	44990	52320
			WF	3470	4110	4810	5560	6370	7230	8140	9110	10140	11220	12360	13550	14790	18860	23420	28470	34010	40060	46590
	1	36.00	G	4465	5295	6202	7180	8230	9350	10550	11810	13150	14560	16040	17590	19220	24530	30490	37090	44350	52250	60800
			W	4130	4890	5720	6610	7570	8590	9680	10830	12050	13330	14680	16090	17560	22390	27790	33780	40360	47520	55270
			WF	3645	4325	5055	5850	6700	7610	8570	9600	10680	11820	13020	14280	15590	19880	24690	30030	35890	42260	49160

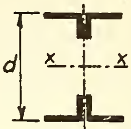
G = Gross Moment of Inertia (I).
W = Net I, 13/16" web holes out.
WF = Net I, 13/16" web and flange holes out.

PLATE GIRDERS

MOMENTS OF INERTIA OF FLANGE ANGLES

AXIS X-X

FOR UNEQUAL ANGLES, SHORT LEGS B. TO B.



6 x 6
7 x 3½

SIZE	THICKNESS	GROSS AREA 4 ANGLES	I	Distance Back to Back of Angles, "d", Inches																		
				24½	26½	28½	30½	32½	34½	36½	38½	40½	42½	44½	46½	48½	54½	60½	66½	72½	78½	84½
6 x 6	3/8	17.44	G	2025	2410	2835	3290	3780	4310	4870	5470	6100	6770	7470	8210	8980	11500	14340	17490	20950	24730	28820
			W	1900	2260	2655	3080	3540	4030	4550	5100	5690	6310	6960	7640	8360	10700	13330	16250	19460	22960	26750
			WF	1710	2035	2395	2780	3200	3640	4120	4630	5160	5730	6320	6940	7600	9740	12140	14810	17750	20960	24430
	7/16	20.24	G	2340	2790	3280	3810	4380	4990	5640	6330	7070	7840	8650	9510	10400	13330	16620	20270	24290	28670	33420
			W	2195	2615	3070	3560	4090	4660	5260	5900	6580	7300	8050	8850	9680	12390	15440	18820	22540	26600	31000
			WF	1975	2355	2765	3215	3700	4210	4760	5350	5970	6620	7310	8030	8790	11270	14060	17150	20560	24270	28290
	½	23.00	G	2650	3160	3715	4315	4960	5660	6400	7180	8010	8890	9110	10780	11800	15120	18850	23000	27570	32540	37940
			W	2485	2955	3470	4030	4630	5270	5960	6690	7460	8270	8430	10030	10970	14050	17510	21350	25570	30180	35170
			WF	2230	2660	3130	3635	4180	4770	5390	6060	6760	7500	7580	9100	9960	12770	15930	19440	23310	27520	32080
	9/16	25.72	G	2945	3515	4135	4805	5530	6300	7130	8000	8930	9910	10940	12020	13160	16870	21040	25670	30770	36330	42360
			W	2760	3285	3860	4485	5150	5870	6640	7450	8310	9220	10170	11170	12220	15660	19520	23810	28530	33680	39250
			WF	2475	2955	3475	4045	4650	5300	6000	6740	7520	8350	9220	10140	11090	14230	17750	21670	25980	30690	35780
	5/8	28.44	G	3245	3870	4555	5295	6090	6950	7860	8830	9850	10930	12070	13270	14520	18620	23230	28350	33990	40130	46790
			W	3035	3620	4255	4940	5680	6470	7320	8210	9160	10160	11220	12330	13490	17280	21550	26280	31500	37180	43340
			WF	2725	3250	3830	4450	5120	5840	6610	7430	8290	9210	10170	11180	12230	15690	19580	23910	28670	33860	39490
	11/16	31.12	G	3535	4220	4965	5775	6650	7580	8580	9640	10760	11940	13180	14490	15860	20340	25380	30980	37150	43870	51150
			W	3305	3940	4635	5385	6190	7060	7980	8960	10000	11090	12240	13450	14720	18870	23530	28710	34400	40620	47350
			WF	2965	3540	4170	4850	5580	6370	7210	8100	9040	10040	11090	12190	13350	17130	21380	26100	31300	36980	43120
	¾	33.76	G	3815	4555	5360	6240	7180	8190	9270	10420	11630	12910	14260	15680	17160	22010	27480	33550	40230	47510	55410
			W	3565	4250	5000	5810	6690	7620	8620	9680	10800	11990	13240	14550	15920	20410	25460	31070	37240	43970	51260
			WF	3195	3815	4495	5230	6020	6870	7780	8750	9770	10840	11980	13170	14420	18510	23110	28230	33860	40000	46650
	13/16	36.36	G	4090	4885	5755	6700	7710	8800	9960	11190	12500	13880	15330	16850	18450	23670	29550	36080	43270	51120	59610
			W	3820	4560	5365	6235	7170	8180	9250	10390	11600	12880	14220	15630	17100	21930	27360	33400	40030	47270	55120
			WF	3420	4090	4820	5610	6460	7370	8350	9380	10480	11640	12860	14140	15480	19880	24830	30330	36380	42980	50140
	7/8	38.92	G	4360	5210	6140	7145	8230	9390	10630	11950	13350	14820	16370	18000	19710	25300	31590	38580	46260	54660	63750
			W	4070	4860	5720	6650	7650	8730	9870	11090	12380	13740	15180	16680	18260	23420	29230	35680	42780	50520	58910
			WF	3645	4355	5135	5975	6890	7860	8900	10010	11180	12420	13720	15090	16520	21220	26510	32380	38850	45910	53550
	15/16	41.48	G	4630	5535	6525	7595	8750	9990	11310	12710	14190	15760	17410	19150	20970	26920	33610	41060	49250	58190	67870
			W	4320	5155	6070	7060	8130	9270	10490	11790	13160	14610	16130	17740	19410	24910	31090	37960	45510	53750	62690
			WF	3865	4620	5445	6345	7310	8350	9450	10630	11880	13190	14580	16030	17560	22550	28180	34430	41310	48820	56960
	1	44.00	G	4890	5850	6895	8030	9250	10560	11960	13450	15020	16690	18440	20270	22200	28510	35610	43500	52180	61650	71920
			W	4560	5445	6415	7460	8590	9800	11090	12470	13920	15460	17070	18770	20540	26360	32910	40190	48190	56930	66390
			WF	4075	4875	5750	6700	7720	8820	9990	11240	12550	13950	15410	16960	18570	23860	29810	36430	43720	51670	60290
7 x 3½	3/8	15.20	G	2030	2395	2790	3220	3680	4160	4680	5230	5810	6410	7050	7720	8420	10700	13260	16090	19190	22570	26220
			W	1895	2230	2595	2990	3410	3860	4330	4840	5370	5930	6520	7130	7770	9870	12210	14810	17650	20750	24090
			WF	1700	2005	2335	2690	3070	3480	3910	4360	4840	5350	5880	6430	7010	8910	11030	13370	15940	18740	21770
	7/16	17.60	G	2345	2765	3225	3715	4240	4810	5410	6040	6710	7410	8150	8930	9740	12380	15330	18610	22200	26100	30330
			W	2180	2570	2995	3445	3930	4450	5000	5580	6200	6850	7520	8240	8980	11400	14110	17110	20400	23980	27850
			WF	1960	2310	2690	3100	3540	4010	4500	5030	5580	6170	6780	7420	8090	10280	12730	15440	18410	21650	25140
	½	20.00	G	2650	3130	3645	4205	4800	5440	6120	6840	7600	8400	9240	10120	11030	14030	17390	21100	25180	29620	34410
			W	2465	2905	3385	3900	4450	5040	5660	6320	7020	7750	8520	9330	10170	12920	15990	19400	23130	27190	31580
			WF	2215	2610	3040	3505	4000	4530	5090	5690	6320	6980	7670	8400	9160	11640	14420	17490	20860	24530	28490
	9/16	22.36	G	2930	3485	4065	4690	5360	6070	6830	7630	8480	9370	10310	11290	12320	15660	19410	23570	28120	33080	38440
			W	2745	3235	3770	4340	4960	5610	6310	7050	7820	8640	9500	10400	11340	14410	17840	21640	25810	30350	35250
			WF	2460	2905	3385	3900	4460	5050	5670	6340	7040	7770	8550	9360	10210	12980	16070	19500	23260	27360	31780
	5/8	24.68	G	3245	3835	4475	5160	5900	6680	7520	8400	9340	10320	11360	12440	13570	17260	21400	25980	31000	36470	42380
			W	3015	3555	4145	4775	5450	6170	6940	7750	8610	9510	10460	11450	12490	15870	19650	23840	28440	33440	38840
			WF	2705	3190	3720	4290	4900	5550	6240	6970	7740	8550	9410	10300	11230	14280	17690	21470	25610	30120	34990
	11/16	27.00	G	3530	4175	4870	5620	6430	7290	8200	9160	10180	11260	12390	13570	14807	18840	23360	28370	33860	39840	46300
			W	3280	3870	4510	5200	5940	6730	7560	8450	9380	10370	11400	12480	13620	17310	21440	26020	31040	36500	42400
			WF	2940	3470	4045	4665	5330	6040	6790	7590	8430	9320	10250	11220	12240	15570	19290	23410	27930	32860	38180
	¾	29.24	G	3810	4505	5260	6070	6940	7870	8860	9900	11010	12170	13390	14670	16010	20370	25260	30680	36630	43100	50090
			W	3535	4175	4865	5610	6410	7260	8160	9120	10130	11200	12310	13490	14710	18700	23170	28120	33550	39450	45840
			WF	3165	3740	4360	5030	5750	6510	7330	8190	9100	10050	11060	12110	13210	16800	20830	25280	30170	35490	41240
	13/16	31.48	G	4090	4835	5645	6515	7450	8450	9510	10640	11830	13080	14390	15770	17200	21900	27160	32990	39390	46350	53880
			W	3780	4475	5220	6020	6880	7790	8760	9790	10880	12020	13220	14480	15800	20090	24890	30210	36050	42400	49270
			WF	3390	4005	4675	5390	6160	6980	7860	8780	9760	10790	11870	13000	14180	18040	22360	27150	32400	38110	44290
	7/8	33.68	G	4360	5155	6020	6955	7950	9020	10150	11360	12630	13960	15370	16840	18380	23390	29020	35250	42090	49540	57590
			W	4035	4770	5560	6415	7330	8310	9350	10450	11610	12830	14110	15450	16860	21440	26580	32260	38500	45290	52630
			WF	3610	4265	4975	5745	6570	7440	8370	9360	10400	11500	12650	13860	15120	19240	23850	28960	34570	40670	47270
	15/16	35.88	G	4620	5465	6385	7375	8440	9570	10780	12060	13410	14830	16320	17890	19520	24870	30850	37490	44760	52690	61260
			W	4275	5050	5895	6800	7770	8810	9910	11080	12320	13610	14980	16410	17900	22770	28230	34280	40920	48140	55940
			WF	3820	4515	5270	6085	6960	7890	8880	9930	11030	12200	13420	14700	16040	20420	25320	30760	36710	43200	50220
	1	38.00	G	4875	5770	6740	7790	8910	10110	11390	12740	14170	15670	17250	18910	20640	26290	32630	39650	47360	55740	64820
			W	4505	5325	6215	7175	8200	9300	10470	11700	13000	14380	15820	17330	18910	24060	29840	36230	43250	50890	59150
			WF	4025	4760	5555	6415	7340	8320	9360	10470	11640	12870	14160	15520	16940	21560	26740	32480	38780	45630	53040

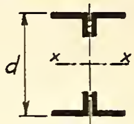
G = Gross Moment of Inertia (I).
W = Net M. of I, 13/16″ web holes out.
WF = Net M. of I, 13/16″ web and flange holes out.

PLATE GIRDERS

MOMENTS OF INERTIA OF FLANGE ANGLES

AXIS X-X

FOR UNEQUAL ANGLES, SHORT LEGS B. TO B.



8 x 6
8 x 8

SIZE	THICKNESS	GROSS AREA 4 ANGLES	I	Distance Back to Back of Angles, Inches																		
				24½	26½	28½	30½	32½	34½	36½	38½	40½	42½	48½	54½	60½	66½	72½	78½	84½	90½	96½
8 x 6	7/16	23.72	G	2845	3380	3965	4595	5270	6000	6770	7590	8460	9380	12410	15710	19750	24060	28800	33970	39560	45580	52030
			W	2700	3205	3750	4345	4980	5670	6390	7160	7980	8840	11680	14780	18570	22620	27060	31900	37140	42790	48830
			WF	2445	2945	3450	4000	4590	5220	5890	6610	7370	8160	10800	13660	17190	20950	25070	29570	34440	39680	45290
	½	27.00	G	3225	3835	4495	5215	5990	6810	7690	8620	9610	10650	14100	17860	22450	27360	32750	38630	44990	51840	59170
			W	3060	3630	4255	4930	5650	6430	7260	8130	9060	10040	13270	16790	21100	25700	30750	36260	42220	48640	55510
			WF	2805	3335	3910	4535	5210	5920	6690	7500	8360	9260	12260	15510	19530	23800	28490	33600	39140	45100	51480
	9/16	30.24	G	3590	4270	5010	5815	6675	7600	8580	9625	10730	11890	15750	19950	25090	30580	36610	43190	50310	57980	66190
			W	3405	4045	4740	5495	6300	7170	8090	9070	10110	11200	14820	18750	23580	28720	34370	40530	47200	54380	62070
			WF	3120	3710	4355	5050	5800	6600	7460	8360	9320	10330	13690	17320	21810	26580	31820	37540	43730	50400	57540
	⅝	33.44	G	3955	4705	5525	6410	7360	8380	9465	10620	11840	13120	17380	22030	27710	33770	40440	47710	55800	64050	73130
			W	3745	4455	5220	6055	6950	7900	8920	10000	11150	12350	16350	20690	26020	31700	37950	44760	52340	60060	68550
			WF	3435	4085	4795	5565	6390	7280	8220	9220	10280	11400	15090	19100	24060	29330	35120	41440	48500	55640	63520
	11/16	36.60	G	4310	5135	6025	6995	8030	9150	10330	11590	12930	14330	18990	24070	30280	36920	44210	52160	60770	70040	79970
			W	4085	4895	5695	6605	7580	8620	9740	10920	12170	13490	17850	22600	28430	34640	41470	48910	56970	65640	74930
			WF	3740	4455	5230	6070	6970	7940	8970	10060	11220	12440	16480	20860	26280	32040	38370	45270	52740	60790	69410
	¾	39.76	G	4665	5555	6525	7575	8700	9910	11200	12570	14010	15540	20590	26110	32850	40050	47970	56600	65950	76020	86800
			W	4415	5255	6165	7150	8210	9340	10550	11830	13190	14620	19350	24500	30830	37570	44980	53060	61810	71220	81300
			WF	4045	4820	5660	6565	7550	8590	9710	10890	12150	13470	17860	22600	28490	34730	41600	49090	57200	65930	75290
	13/16	42.88	G	5005	5960	7005	8135	9350	10650	12030	13510	15060	16710	22150	28090	35350	43110	51640	60950	71020	81870	93490
			W	4735	5630	6610	7670	8810	10030	11330	12710	14170	15710	20800	26350	33160	40420	48410	57110	66530	76670	87540
			WF	4335	5165	6065	7045	8100	9220	10420	11700	13050	14470	19190	24300	30630	37360	44750	52820	61550	70950	81030
	⅞	45.92	G	5340	6360	7475	8685	9980	11370	12850	14430	16090	17850	23680	30030	37810	46110	55240	65200	75980	87590	100030
			W	5045	6005	7055	8185	9400	10710	12090	13570	15130	16780	22230	28160	35450	43210	51750	61060	71140	82000	93620
			WF	4620	5505	6470	7515	8640	9840	11120	12490	13930	15450	20490	25960	32730	39920	47820	56450	65790	75850	86620
	15/16	49.00	G	5675	6765	7950	9235	10620	12100	13680	15360	17140	19010	25220	32000	40280	49140	58880	69500	81000	93380	106650
			W	5360	6385	7500	8705	10000	11390	12870	14440	16100	17860	23670	29990	37760	46040	55140	65060	75810	87380	99780
			WF	4905	5850	6875	7985	9180	10470	11830	13280	14820	16440	21810	27630	34850	42510	50940	60130	70080	80800	92280
	1	52.00	G	6000	7150	8410	9775	11240	12810	14480	16260	18150	20130	26720	33900	42690	52080	62410	73670	85870	99010	113080
			W	5665	6750	7930	9205	10580	12050	13620	15280	17040	18900	25060	31760	39990	48770	58420	68940	80340	92610	105750
			WF	5180	6180	7265	8445	9710	11070	12510	14050	15680	17390	23090	29250	36900	45020	53950	63690	74240	85600	97770
8 x 8	½	31.00	G	3330	3990	4705	5480	6320	7230	8190	9220	10310	11460	15280	19660	24600	30100	36160	42770	49940	57670	65960
			W	3180	3805	4480	5220	6020	6870	7780	8760	9790	10870	14490	18630	23300	28500	34220	40420	47250	54550	62380
			WF	2930	3505	4140	4825	5570	6360	7220	8120	9090	10100	13480	17360	21730	26590	31950	37760	44160	51010	58350
	9/16	34.72	G	3715	4450	5250	6120	7060	8070	9150	10300	11520	12800	17080	21990	27520	33670	40450	47850	55880	64530	73810
			W	3550	4240	5000	5825	6710	7670	8690	9780	10930	12150	16190	20830	26050	31870	38270	45210	52850	61020	69780
			WF	3265	3910	4615	5385	6210	7100	8060	9070	10150	11280	15060	19400	24290	29730	35720	42220	49380	57040	65250
	⅝	38.44	G	4095	4906	5790	6755	7790	8910	10100	11370	12720	14140	18880	24300	30420	37230	44730	52920	61800	71380	81650
			W	3910	4675	5515	6425	7410	8470	9590	10800	12070	13420	17890	23020	28790	35220	42310	49990	58430	67480	77170
			WF	3600	4310	5090	5940	6850	7840	8890	10010	11200	12460	16640	21430	26830	32850	39480	46670	54590	63060	72140
	11/16	42.12	G	4470	5355	6325	7375	8510	9740	11040	12430	13910	15460	20650	26580	33280	40740	48950	57920	67650	78140	89590
			W	4265	5100	6020	7015	8090	9250	10480	11800	13190	14660	19560	25170	31490	38530	46290	54690	63940	73840	84460
			WF	3925	4700	5555	6480	7480	8560	9710	10940	12240	13610	18180	23430	29340	35930	43190	51050	59720	68990	78940
	¾	45.76	G	4830	5785	6835	7975	9210	10530	11950	13460	15060	16750	22370	28810	36080	44170	53080	62820	73390	84770	96980
			W	4605	5510	6505	7585	8750	10000	11340	12760	14280	15870	21180	27270	34130	41770	50180	59300	69340	80090	91610
			WF	4235	5075	6000	7000	8090	9250	10500	11830	13240	14730	19690	25370	31790	38930	46800	55340	64740	74800	85590
	13/16	49.36	G	5185	6215	7350	8575	9900	11330	12860	14480	16200	18020	24080	31030	38860	47580	57190	67690	79080	91350	104520
			W	4945	5920	6990	8150	9410	10750	12200	13730	15360	17080	22800	29350	36750	44980	54050	63880	74700	86280	98700
			WF	4545	5450	6445	7525	8690	9950	11290	12720	14240	15840	21180	27310	34210	41910	50390	59590	69720	80560	92190
	⅞	52.92	G	5535	6640	7850	9165	10590	12110	13750	15490	17330	19280	25770	33210	41600	50950	61240	72490	84690	97850	111960
			W	5275	6320	7460	8705	10050	11490	13040	14680	16420	18260	24390	31410	39330	48140	57860	68390	79980	92380	105690
			WF	4845	5815	6880	8035	9280	10630	13060	13590	15220	16940	22650	29210	36600	44850	53930	63770	74620	86230	98680
	15/16	56.48	G	5885	7060	8350	9750	11270	12890	14630	16490	18450	20530	27450	35380	44330	54300	65280	77280	90300	104330	119380
			W	5605	6715	7935	9260	10690	12230	13870	15620	17480	19440	25970	33450	41900	51300	61660	72880	85240	98480	112660
			WF	5150	6180	7310	8540	9870	11310	12830	14470	16190	18020	24110	31100	38990	47770	57450	67950	79520	91900	105170
	1	60.00	G	6215	7460	8825	10310	11920	13640	15490	17450	19540	21740	29080	37500	46990	57570	69230	81960	95780	110680	126650
			W	5915	7090	8380	9785	11300	12930	14670	16530	18500	20580	27500	35440	44400	54370	65360	77270	90390	104430	119490
			WF	5430	6520	7720	9025	10430	11950	13570	13300	17130	19070	25530	32940	41300	50610	60890	72020	84290	97420	111510
	1 1/16	63.48	G	6545	7860	9305	10870	12570	14390	16340	18420	20620	22950	30710	39610	49650	60830	73150	86620	101230	116990	133880
			W	6230	7470	8830	10315	11920	13640	15480	17440	19520	21720	29030	37420	46890	57430	69040	81640	95500	110350	126270
			WF	5715	6870	8130	9510	11000	12600	14310	16130	18070	20120	26940	34760	43600	53450	64300	76060	89030	102910	117800
	1⅛	66.92	G	6870	8255	9775	11425	13210	15130	17180	19370	21690	24150	32310	41680	52260	64040	77030	91220	106610	123210	141010
			W	6535	7840	9275	10835	12520	14330	16270	18330	20520	22830	30530	39370	49340	60440	72670	85940	100540	116180	132950
			WF	5995	7205	8535	9985	11550	13230	15040	16950	18990	21150	28330	36560	45870	56230	67660	80040	93700	108320	124000

For Reference: Rivets
AISC Shear = 15,000
Bearing S.S. = 32,000
Bearing D.S. = 40,000

RIVET AND BOLT
SHEAR AND BEARING VALUES

For Reference: Unfinished Bolts
AISC Shear = 10,000
Bearing S.S. = 20,000
Bearing D.S. = 25,000

SHEAR

Allowable Loads in Kips

RIVET DIAM.	ALLOWABLE SINGLE AND DOUBLE SHEAR VALUES FOR SHEARS SHOWN																RIVET DIAM.
	7500		8000		9000		10000		11000		12000		13500		15000		
	Single	Double	Single	Double	Single	Double	Single	Double	Single	Double	Single	Double	Single	Double	Single	Double	
⅜	.83	1.66	.88	1.77	.99	1.99	1.10	2.21	1.21	2.43	1.32	2.65	1.49	2.98	1.66	3.32	⅜
½	1.47	2.95	1.57	3.14	1.77	3.53	1.96	3.93	2.16	4.32	2.36	4.71	2.65	5.30	2.95	5.89	½
⅝	2.30	4.60	2.45	4.91	2.76	5.52	3.07	6.14	3.38	6.75	3.68	7.36	4.14	8.28	4.60	9.20	⅝
¾	3.31	6.63	3.53	7.07	3.98	7.95	4.42	8.84	4.86	9.72	5.30	10.60	5.96	11.93	6.63	13.25	¾
⅞	4.51	9.02	4.81	9.62	5.41	10.82	6.01	12.03	6.62	13.23	7.22	14.43	8.12	16.24	9.02	18.04	⅞
1	5.89	11.78	6.28	12.57	7.07	14.14	7.85	15.71	8.64	17.28	9.43	18.85	10.60	21.21	11.78	23.56	1
1⅛	7.46	14.91	7.95	15.90	8.95	17.89	9.94	19.88	10.93	21.87	11.93	23.86	13.42	26.84	14.91	29.82	1⅛
1¼	9.20	18.40	9.82	19.64	11.04	22.09	12.27	24.54	13.50	27.00	14.73	29.54	16.57	33.13	18.40	36.80	1¼

BEARING

t = Thickness of metal

Allowable Loads in Kips

RIV. DIAM.	t	ALLOWABLE BEARING AT UNIT VALUE SHOWN							
		16000	18000	20000	24000	25000	30000	32000	40000
⅜″	⅛	.75	.85	.94	1.31	1.17	1.41	1.50	1.88
	3/16	1.13	1.27	1.41	1.69	1.75	2.11	2.24	2.80
	¼	1.50	1.69	1.88	2.25	2.34	2.82	3.00	3.75
	5/16	1.88	2.11	2.35	2.82	2.94	3.52	3.75	4.70
	⅜	2.25	2.53	2.81	3.38	3.52	4.22	4.50	5.63
	7/16	2.63	2.95	3.28	3.94	4.10	4.92	5.25	6.56
⅝″	⅛	1.25	1.41	1.57	1.88	1.95	2.35	2.50	3.12
	3/16	1.88	2.11	2.35	2.82	2.92	3.52	3.75	4.69
	¼	2.50	2.82	3.13	3.75	3.90	4.69	5.00	6.25
	5/16	3.13	3.52	3.91	4.69	4.88	5.86	6.23	7.80
	⅜	3.75	4.22	4.69	5.63	5.85	7.03	7.48	9.35
	7/16	4.38	4.92	5.47	6.57	6.83	8.21	8.75	10.93
	½	5.00	5.63	6.25	7.50	7.80	9.38	10.00	12.50
	9/16	5.63	6.33	7.03	8.44	8.78	10.55	11.25	14.05
	⅝	6.25	7.04	7.82	9.40	9.77	11.76	12.50	15.63
⅞″	¼	3.50	3.94	4.38	5.25	5.47	6.57	7.00	8.75
	5/16	4.38	4.92	5.47	6.57	6.84	8.21	8.75	10.90
	⅜	5.25	5.91	6.57	7.88	8.20	9.85	10.50	13.10
	7/16	6.13	6.89	7.66	9.19	9.57	11.49	12.25	15.31
	½	7.00	7.88	8.75	10.50	10.94	13.13	14.00	17.50
	9/16	7.88	8.86	9.85	11.82	12.30	14.77	15.75	19.69
	⅝	8.75	9.85	10.94	13.13	13.67	16.41	17.50	21.88
	11/16	9.63	10.83	12.03	14.44	15.04	18.05	19.25	24.06
	¾	10.50	11.82	13.13	15.75	16.41	19.69	21.00	26.25
1⅛″	⅜	6.75	7.59	8.44	10.13	10.55	12.66	13.50	16.88
	7/16	7.88	8.86	9.85	11.82	12.30	14.77	15.75	19.69
	½	9.00	10.13	11.25	13.50	14.06	16.88	18.00	22.50
	9/16	10.13	11.39	12.66	15.19	15.82	18.99	20.25	25.31
	⅝	11.25	12.66	14.07	16.88	17.58	21.10	22.50	28.13
	11/16	12.38	13.92	15.47	18.57	19.34	23.21	24.75	30.94
	¾	13.50	15.19	16.88	20.25	21.09	25.32	27.00	33.75
	13/16	14.63	16.46	18.28	21.94	22.85	27.42	29.25	36.56
	⅞	15.75	17.72	19.69	23.63	24.61	29.53	31.50	39.38
	15/16	16.88	18.99	21.10	25.32	26.37	31.64	33.75	42.19

RIV. DIAM.	t	ALLOWABLE BEARING AT UNIT VALUE SHOWN							
		16000	18000	20000	24000	25000	30000	32000	40000
½″	⅛	1.00	1.13	1.25	1.50	1.56	1.88	2.00	2.50
	3/16	1.50	1.69	1.88	2.25	2.34	2.82	3.00	3.75
	¼	2.00	2.25	2.50	3.00	3.13	3.75	4.00	5.00
	5/16	2.50	2.82	3.13	3.75	3.91	4.69	5.00	6.25
	⅜	3.00	3.38	3.75	4.50	4.69	5.63	6.00	7.50
	7/16	3.50	3.94	4.38	5.25	5.47	6.57	7.00	8.75
¾″	3/16	2.25	2.53	2.82	3.38	3.52	4.22	4.50	5.65
	¼	3.00	3.38	3.75	4.50	4.69	5.63	6.00	7.50
	5/16	3.75	4.22	4.69	5.63	5.95	7.14	7.62	9.53
	⅜	4.50	5.07	5.63	6.75	7.03	8.44	9.00	11.25
	7/16	5.25	5.91	6.57	7.88	8.70	9.85	10.50	13.13
	½	6.00	6.75	7.50	9.00	9.38	11.25	12.00	15.00
	9/16	6.75	7.60	8.44	10.13	10.55	12.66	13.50	16.88
	⅝	7.50	8.44	9.38	11.25	11.72	14.07	15.00	18.75
	11/16	8.25	9.28	10.32	12.38	12.89	15.47	16.50	20.63
1″	5/16	5.00	5.63	6.25	7.50	7.81	9.38	10.00	12.50
	⅜	6.00	6.75	7.50	9.00	9.38	11.25	12.00	15.00
	7/16	7.00	7.88	8.75	10.50	10.94	13.13	14.00	17.50
	½	8.00	9.00	10.00	12.00	12.50	15.00	16.00	20.00
	9/16	9.00	10.13	11.25	13.50	14.06	16.88	18.00	22.50
	⅝	10.00	11.25	12.50	15.00	15.63	18.75	20.00	25.00
	11/16	11.00	12.38	13.75	16.50	17.19	20.63	22.00	27.50
	¾	12.00	13.50	15.00	18.00	18.75	22.50	24.00	30.00
	13/16	13.00	14.63	16.25	19.50	20.31	24.38	26.00	32.50
1¼″	7/16	8.75	9.84	10.94	13.13	13.67	16.41	17.50	21.90
	½	10.00	11.25	12.50	15.00	15.63	18.75	20.00	25.00
	9/16	11.25	12.66	14.06	16.88	17.58	21.09	22.50	28.13
	⅝	12.50	14.06	15.63	18.75	19.53	23.44	25.00	31.75
	11/16	13.75	15.47	17.19	20.63	21.48	25.78	27.50	34.38
	¾	15.00	16.88	18.75	22.50	23.44	28.13	30.00	37.50
	13/16	16.25	18.28	20.31	24.38	25.39	30.47	32.50	40.63
	⅞	17.50	19.69	21.88	26.25	27.34	32.81	35.00	43.75
	15/16	18.75	21.09	23.44	28.13	29.30	35.16	37.50	46.88
	1	20.00	22.50	25.00	30.00	31.75	37.50	40.00	50.00

For Tension Members:
Hole = Diameter of rivet + ⅛″

REDUCTION OF AREA FOR RIVET HOLES
AREA IN SQUARE INCHES = DIAMETER HOLE BY METAL THICKNESS

DIAM. HOLE	THICKNESS OF METAL, INCHES																						DIAM. HOLE
	3/16	¼	5/16	⅜	7/16	½	9/16	⅝	11/16	¾	13/16	⅞	15/16	1	1 1/16	1⅛	1 3/16	1¼	1 5/16	1⅜	1 7/16	1½	
½	.09	.13	.16	.19	.22	.25	.28	.31	.34	.38													½
9/16	.11	.14	.18	.21	.25	.28	.32	.35	.39	.42													9/16
⅝	.12	.16	.20	.23	.27	.31	.35	.39	.43	.47	.51	.55	.59	.63									⅝
11/16	.13	.17	.21	.26	.30	.34	.39	.43	.47	.52	.56	.60	.64	.69									11/16
¾	.14	.19	.23	.28	.33	.38	.42	.47	.52	.56	.61	.66	.70	.75	.80	.84	.89	.94					¾
13/16	.15	.20	.25	.30	.36	.41	.46	.51	.56	.61	.66	.71	.76	.81	.86	.91	.96	1.02					13/16
⅞	.16	.22	.27	.33	.38	.44	.49	.55	.60	.66	.71	.77	.82	.88	.93	.98	1.04	1.09	1.15	1.20	1.26	1.31	⅞
15/16	.18	.23	.29	.35	.41	.47	.53	.59	.64	.70	.76	.82	.88	.94	1.00	1.05	1.11	1.17	1.23	1.29	1.35	1.41	15/16
1	.19	.25	.31	.38	.44	.50	.56	.63	.69	.75	.81	.88	.94	1.00	1.06	1.13	1.19	1.25	1.31	1.38	1.44	1.50	1
1 1/16	.20	.27	.33	.40	.46	.53	.60	.66	.73	.80	.86	.93	1.00	1.06	1.13	1.20	1.26	1.33	1.39	1.46	1.53	1.59	1 1/16
1⅛	.21	.28	.35	.42	.49	.56	.63	.70	.77	.84	.91	.98	1.05	1.13	1.20	1.27	1.34	1.41	1.48	1.55	1.62	1.69	1⅛
1¼	.23	.31	.39	.47	.55	.63	.70	.78	.86	.94	1.02	1.09	1.17	1.25	1.33	1.41	1.48	1.56	1.64	1.72	1.80	1.88	1¼

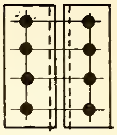
"A" Series—⅞" Rivets
"B" Series—¾" Rivets

STANDARD BEAM CONNECTIONS

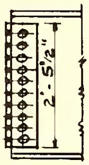
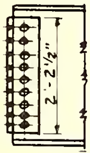
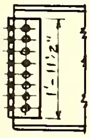
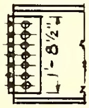
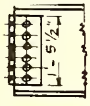
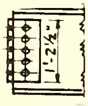
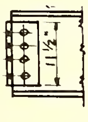
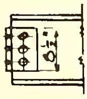
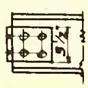
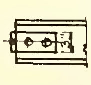
RIVETED

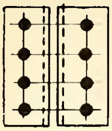
ALLOWABLE LOADS IN KIPS

Web Bearing or Shear Governs Maximum Values Shown



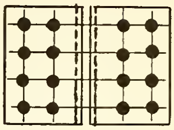
O.S. Legs

	¾" RIVETS (13/16" Holes)—B-Series								⅞" RIVETS (15/16" Holes)—A-Series							
	RIVETS-O.S.		RIVETS-WEB		MAXIMUM VALUE				RIVETS-O.S.		RIVETS-WEB		MAXIMUM VALUE			
	No.	Shear	Bear.	Shear	Section	R			No.	Shear	Bear.	Shear	Section	R		
 A10—For ⅞ Riv. B10—For ¾ Riv. 2Ls—4x3½x7/16	20	132.5	300t t = Web Thickness	132.5	36 WF All Weights	132.5			20	180.4	350t t = Web Thickness	180.4	36 WF All Weights	180.4		
 A9—For ⅞ Riv. B9—For ¾ Riv. 2Ls—4x3½x7/16	18	119.3	270t	119.3	33 WF All Weights	119.3			18	162.4	315t	162.4	33 WF All Weights	162.4		
 A8—For ⅞ Riv. B8—For ¾ Riv. 2Ls—4x3½x7/16	16	106.0	240t	106.0	30 WF All Weights	106.0			16	144.3	280t	144.3	30 WF All Weights	144.3		
 A7—For ⅞ B7—For ¾ 2Ls—4x3½x7/16	14	92.8	210t	92.8	27 WF All Weights				14	126.3	245t	126.3	27 WF 102 to 177 94	126.3 120.0		
					Section	R	Section	R					Section	R	Section	R
 A6—For ⅞ B6—For ¾ 2Ls—4x3½x7/16	12	79.5	180t	79.5	24 WF 84-160 76	79.5 79.2	24 I All Wts.	79.5	12	108.2	210t	108.2	24 WF 120-160 110 100 94 84 76	108.2 107.1 98.3 108.4 98.6 92.4	24 I 90-120 79.9	108.2 105.0
 A5—For ⅞ B5—For ¾ 2Ls—4x3½x7/16	10	66.3	150t	66.3	21 WF 73-142 68 62	66.3 64.5 60.0	20 I All Wts.	66.3	10	90.2	175t	90.2	21 WF 96-142 82 73 68 62	90.2 87.3 79.6 75.3 70.0	20 I 75-95 65.4	90.2 87.5
 A4—For ⅞ B4—For ¾ 2Ls—4x3½x⅜	8	53.0	120t	53.0	18 WF 77-114 70 64 60 55 50 16 WF 64-96 58 50 45 40 36	53.0 52.6 48.4 49.9 46.8 43.0 53.0 48.8 45.6 41.5 36.8 35.9	18 I All Wts. 15 I 50 42.9	53.0 53.0 49.2	8	72.2	140t	72.2	18 WF 105-114 96 85 77 70 64 60 55 50 16 WF 96 88 78	72.2 71.7 72.2 66.5 61.3 56.4 58.3 54.6 50.1 72.2 70.6 72.2	16 WF 71 64 58 50 45 40 36 18 I 70 54.7 15 I 50 42.9	68.0 62.0 57.0 53.2 48.4 43.0 41.9 72.2 64.4 72.2 57.4
 A3—For ⅞ B3—For ¾ 2Ls—4x3½x⅜	6	39.8	90t	39.8	14 WF 38 34 30 12 WF 36 31 27	28.2 25.8 24 3 27.5 23.8 21.6	12 I 50 40.8 35 31.8	39.8 39.8 38.5 31.5	6	54.1	105t	54.1	14 WF 38 34 30 12 WF 36 31 27	32.9 30.2 28.4 32.0 27.8 25.2	12 I 50 40.8 35 31.8	54.1 48.3 44.9 36.8
 A2—For ⅞ B2—For ¾ 2Ls—6x4x⅜	4	26.5	120t	53.0	10 WF All Wts. 8 WF 20 17	26.5 26.2 23.9	10 I All Wts. 8 I All Wts.	26.5 26.5	4	36.1	140t	72.2	10 WF 29 25 21 8 WF 20 17	36.1 33.0 30.9 26.2 23.9	10 I 8 I 23.0 18.4	36.1 36.1 28.1
 A1—⅞ Riv. B1—¾ Riv. 2Ls—6x4x⅜	2	13.3	60t	26.5	7 I 20 15.3 6 I 17.25 12.5	13.3 13.3 13.3 13.3	5 I 14.75 10	13.3 12.6	2	18.0	70t	36.1	7 I 20 15.3 6 I 17.25 12.5	18.0 17.5 18.0 16.1	5 I 14.75 10	18.0 13.7



HEAVY BEAM CONNECTIONS

RIVETED



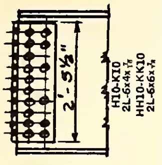
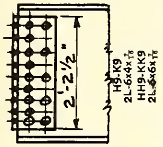
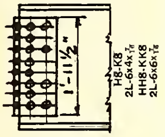
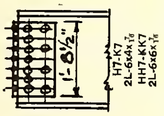
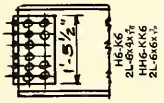
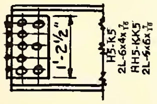
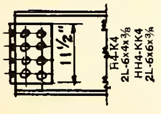
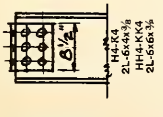
H & HH = ⅞" Rivets
K & KK = ¾" Rivets

ALLOWABLE LOADS IN KIPS

H/K } = 2 Lines Rivets—O.S. Legs

Web Bearing or Shear Governs Maximum Values Shown

HH/KK } = 4 Lines Rivets—O.S. Legs

	¾" RIVETS ($\frac{13}{16}$" Holes) K & KK Series								
	RIVETS-O.S. LEG				RIVETS WEB LEG		MAXIMUM VALUE		
	K		KK		Bear.	Shear	Section	K	KK
	No.	Shear	No.	Shear					
 2'-5½" H10-K10 2L-6x4x7/16 HH10-KK10 2L-6x6x7/16			40	265.1	480t t = Web Thickness	218.1	36 WF All Weights		212.1
 2'-2½" H9-K9 2L-6x4x7/16 HH9-KK9 2L-6x6x7/16			36	238.6	420t	185.6	33 WF All Weights		185.6
 1'-11½" H8-K8 2L-6x4x7/16 HH8-KK8 2L-6x6x7/16			32	212.1	360t	159.0	30 WF All Weights		159.0
 1'-8½" H7-K7 2L-6x4x7/16 HH7-KK7 2L-6x6x7/16			28	185.6	330t	145.8	27 WF All Weights		145.8
 1'-5½" H6-K6 2L-6x4x7/16 HH6-KK6 2L-6x6x7/16	12	79.5	24	159.0	300t	132.5	24 WF All Weights	79.5	132.0
 1'-2½" H5-K5 2L-6x4x7/16 HH5-KK5 2L-6x6x7/16	10	66.3	20	132.5	240t	106.0	21 WF 73-142		106.0
							68	66.3	103.2
							62	66.3	96.0
 11½" H4-K4 2L-6x4x3/8 HH4-KK4 2L-6x6x3/8	8	53.0	16	106.0	240t	106.0	18 WF 77-114		106.0
							70	53.0	102.5
							64	53.0	93.6
							60	53.0	98.7
							55	53.0	91.9
							50	53.0	83.8
							16 WF 96		106.0
							88		105.9
							78		106.0
							71		102.1
							64		92.1
							58	53.0	83.9
							50	53.0	80.3
							45	53.0	72.5
							40	53.0	63.9
							36	53.0	61.6
 8½" H4-K4 2L-6x4x3/8 HH4-KK4 2L-6x6x3/8	6	39.8	12	79.5	180t	79.5	14 WF 38	39.8	56.3
							34	39.8	51.7
							30	39.8	48.6
							12 WF 36	39.8	48.5
							31	39.8	41.6
							27	37.4	37.4

	⅞" RIVETS ($\frac{15}{16}$" Holes) H & HH Series								
	RIVETS-O.S. LEG				RIVETS WEB LEG		MAXIMUM VALUE		
	H		HH		Bear.	Shear	Section	H	HH
	No.	Shear	No.	Shear					
H10-K10 2L-6x4x7/16 HH10-KK10 2L-6x6x7/16			40	360.8	560t t = Web Thickness	288.6	36 WF All Weights		288.6
H9-K9 2L-6x4x7/16 HH9-KK9 2L-6x6x7/16			36	324.7	490t	252.6	33 WF 141-240		252.6
							130		249.6
H8-K8 2L-6x4x7/16 HH8-KK8 2L-6x6x7/16			32	288.6	420t	216.5	30 WF 116-210		216.5
							108		212.4
H7-K7 2L-6x4x7/16 HH7-KK7 2L-6x6x7/16			28	252.6	385t	198.4	27 WF 114-177		198.4
							102		182.3
							94		171.4
H6-K6 2L-6x4x7/16 HH6-KK6 2L-6x6x7/16			24	216.5	350t	180.4	24 WF 145-160		180.4
							130		178.1
							120		175.7
							110		160.2
							100		146.0
							94		162.9
							84		147.2
							76		136.8
H5-K5 2L-6x4x7/16 HH5-KK5 2L-6x6x7/16	10	90.2	20	180.4	280t	144.3	21 WF 127-142		144.3
							112		143.9
							96		144.3
							82	90.2	135.3
							73	90.2	125.6
							68	90.2	118.1
							62	90.2	109.2
H4-K4 2L-6x4x3/8 HH4-KK4 2L-6x6x3/8	8	72.2	16	144.3	280t	144.3	18 WF 114		142.9
							105		131.9
							96	72.2	120.9
							85	72.2	125.3
							77	72.2	112.1
							70	72.2	102.5
							64	72.2	93.6
							60	72.2	98.7
							55	72.2	91.9
							50	72.2	83.8
							16 WF 96	72.2	113.5
							88	72.2	105.9
							78	72.2	112.2
							71	72.2	102.1
							64	72.2	92.1
							58	72.2	83.9
							50	72.2	80.3
							45	72.2	72.5
							40	63.9	63.9
							36	61.6	61.6
H4-K4 2L-6x4x3/8 HH4-KK4 2L-6x6x3/8	6	54.1	12	108.2	210t	108.2	14 WF 38	54.1	57.5
							34	52.2	52.2
							30	48.6	48.6
							12 WF 36	48.5	
							31	41.6	
							27	37.3	

STANDARD BEAM CONNECTIONS

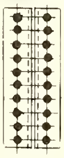
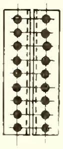
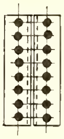
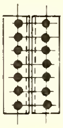
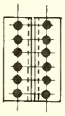
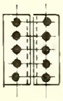
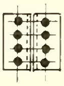
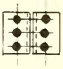
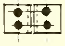
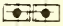
WITH UNFINISHED BOLTS IN OUTSTANDING LEGS

Many cities and other governmental agencies permit the use of unfinished bolts in steel structures, in accordance with the requirements of the Specifications of the American Institute of Steel Construction.

It is obvious that, while the standard connections riveted to the beam, as shown in the tables given elsewhere, correctly give the permitted stresses for such conditions, they cannot be used for the connection when bolts are used in the outstanding legs of the connection. In the latter case the following table may be used, representing the single shear values of unfinished bolts, with a minimum thickness of metal of 5/16″ for ¾″ bolts, and ⅜″ for ⅞″ bolts.

The first condition given is for ordinary machine bolts with no washers, wherein some of the threaded portion of the bolt is in the hole. The A.I.S.C. specification states, "If unfinished bolts are provided with washers under nuts, and have unthreaded shanks extending completely through the joined parts, the shearing and bearing values . . . . may be increased one-eighth."

SINGLE SHEAR VALUE, KIPS

TYPE	SIZE BOLTS	NUMBER BOLTS IN OUTSTANDING LEGS									
		20	18	16	14	12	10	8	6	4	2
											
CASE 1 Ordinary Unfinished Bolts	¾″	88.4	79.5	70.7	61.9	53.0	44.2	35.3	26.5	17.7	8.8
	⅞″	120.3	108.2	96.2	84.2	72.2	60.1	48.1	36.1	24.1	12.0
CASE 2 With Washers and Unthreaded Shanks	¾″	99.4	89.5	79.5	69.6	59.6	49.7	39.8	29.8	19.9	9.9
	⅞″	135.3	121.8	108.2	94.7	81.2	67.6	54.1	40.6	27.1	13.5

Shear 10,000 psi
Bearing: S.S. 20,000
D.S. 25,000

VALUES OF UNFINISHED BOLTS, KIPS

TYPE	DIAMETER	½″	⅝″	¾″	⅞″	1″	1⅛″	1¼″
	AREA	.1963	.3068	.4418	.6013	.7854	.9940	1.2272
CASE 1 Ordinary Unfinished Bolts	SINGLE SHEAR	1.96	3.07	4.42	6.01	7.85	9.94	12.27
	DOUBLE SHEAR	3.93	6.14	8.84	12.03	15.71	19.88	24.54
CASE 2 With Washers and Unthreaded Shanks	SINGLE SHEAR	2.21	3.45	4.97	6.76	8.84	11.18	13.81
	DOUBLE SHEAR	4.42	6.90	9.94	13.53	17.67	22.37	27.61

RIVETS
7/8″

COURTESY, "AMERICAN INSTITUTE OF STEEL CONSTRUCTION"

HOLES
15/16″

SPECIAL BEAM CONNECTIONS

Examples below illustrate methods of designing connections for beams with reactions too large to be carried by Standard Connections.

Value of One Rivet

Single shear in outstanding leg	9.02 Kips
Enclosed bearing on web	35.0 t Kips
Maximum (double shear)	18.04 Kips
Minimum web thickness "t" to develop double shear	0.515 inch.
Minimum web thickness "t" to develop single shear	0.322 inch.

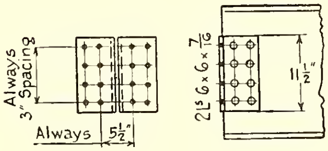
Thin Webs

When web "t" is less than .515″ it may occur that the standard "A" Connection provides sufficient shear capacity in outstanding legs, but insufficient web bearing capacity. For all such cases a standard "H" Connection has been tabulated.

Heavy Shears

When, as by reason of short span or heavy loading the shear exceeds the shear capacity of a standard "A" Connection, three courses are available:

1. If the web rivets of a standard "A" or "H" Connection are adequate for web bearing, use 1″ rivets in its outstanding legs, thus increasing its shear capacity by 30%.
2. Use a standard "HH" Connection as tabulated.
3. Detail both legs, using rivet values at top of this page.



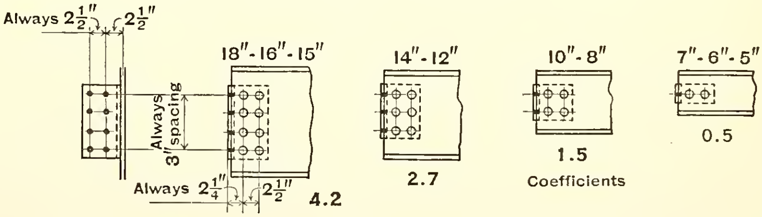
24 WF 130 t = .565″

Shear : 140.0 Kips

O. S. Legs $\frac{140.0}{9.02} = 15.6$ rivets

Web Legs $\frac{140.0}{18.04} = 7.8$ rivets

One-sided Connections



Avoid, where practicable, and do not use for beams over 18″. For capacity, multiply least value of one rivet by coefficient shown. For gages other than those shown, the coefficients will vary and must be computed by the general formula. Eccentricity should be provided for in the outstanding leg only, unless shop riveted leg of angle exceeds 6″ for 7/8″ rivets or smaller, or 7″ for 1″ rivets or larger, when eccentricity should be provided for in both legs.

All the above connections are special and must be detailed.

HOLES $\frac{13}{16}''$

COURTESY, "AMERICAN INSTITUTE OF STEEL CONSTRUCTION"

RIVETS $\frac{3}{4}''$

SPECIAL BEAM CONNECTIONS

Examples below illustrate methods of designing connections for beams with reactions too large to be carried by Standard Connections.

Value of One Rivet

Single shear in outstanding leg	6.63 Kips
Enclosed bearing on web	30.0 t Kips
Maximum (double shear)	13.25 Kips
Minimum web thickness "t" to develop double shear	0.442 inch.
Minimum web thickness "t" to develop single shear	0.276 inch.

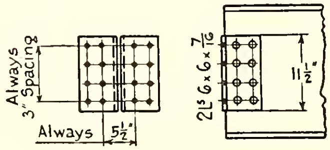
Thin Webs

When web "t" is less than .442″ it may occur that the standard "B" Connections provides sufficient shear capacity in outstanding legs, but insufficient web bearing capacity. For all such cases a standard "K" Connection has been tabulated.

Heavy Shears

When, as by reason of short span or heavy loading, the shear exceeds the shear capacity of a standard "B" Connection, three courses are available:

1. If the web rivets of a standard "B" or "K" Connection are adequate for web bearing, use $\frac{7}{8}''$ rivets in its outstanding legs, thus increasing its shear capacity by 36%.
2. Use a standard "KK" Connection as tabulated.
3. Detail both legs, using rivet values at top of this page.



21 WF 112 t = .527″

Shear : 105.0 Kips

O. S. Legs $\frac{105.0}{6.63} = 15.8$ rivets

Web Legs $\frac{105.0}{13.25} = 7.9$ rivets

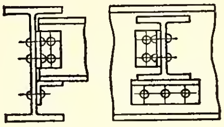
All the above connections are special and must be detailed.

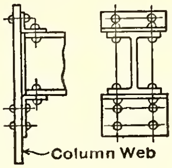
For one sided connections with ¾″ rivets, the same information given for ⅞″ rivets applies.

COURTESY, "AMERICAN INSTITUTE OF STEEL CONSTRUCTION"

BEAM SEATS WITHOUT STIFFENERS

ALLOWABLE LOADS IN KIPS





Outstanding Leg of Angle 4"

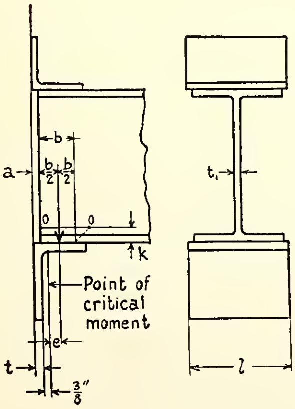
Thickness of Beam Web	Length = 6"						Length = 8"					
	Thickness of Seat Angle						Thickness of Seat Angle					
	3/8"	1/2"	5/8"	3/4"	7/8"	1"	3/8"	1/2"	5/8"	3/4"	7/8"	1"
3/16	6	9	11	14	16		7	10	13	15	16	
1/4	8	11	14	17	20	23	9	12	16	19	22	23
5/16	10	15	18	21	25	28	11	16	20	24	27	31
3/8	11	17	22	26	30	34	12	19	24	28	32	35
7/16	12	18	25	30	34	35	13	21	27	32	35	
1/2	12	20	28	34	35		14	22	31	35		
9/16	14	21	30	35			15	24	34	35		

Above values are to be used only when beam has a top angle or side lug.

For values over 35 kips stiffened beam seats should be used.

Above table is based on effective bearing beginning 1/2" from back of seat angle. Values for seat angles of lengths other than 6" or 8" may be interpolated from the above table.

The following method of design, using a maximum bending stress of 24,000 pounds per square inch, is recommended. (The 24,000 pound unit stress is used, as the seat angle being fastened to the beam is restrained, and the true moment is somewhat less than for a simple cantilever.)



R = Reaction of beam, in kips.
t = Thickness of seat angle, in inches.
l = Length of seat angle. (Max. effective length = 9")
a = Distance from back of seat angle to beam, in inches.
k = Distance from bottom of beam to top of fillet, in inches.

$$b = \text{Effective length of bearing} = \frac{P}{f_1\, t_1} - k = \frac{P}{24\, t_1} - k,$$

but not less than 1/2 (o-o).
where f_1 = allowable stress at toe of fillet, A.I.S.C. Specification, Sec. 19(h) = 24 kips p. s. i.; and
t_1 = thickness of beam web, in inches.

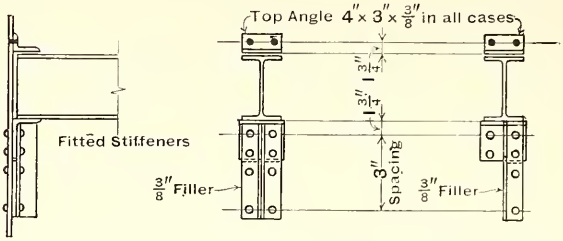
$$e = \frac{b}{2} + a - t - \frac{3}{8}$$

$$M = Re = \frac{24\, lt^2}{6}$$

$$R = \frac{24lt^2}{6e} = \frac{4\, lt^2}{e}$$

COURTESY, "AMERICAN INSTITUTE OF STEEL CONSTRUCTION"

STIFFENED BEAM SEATS



Rivet Diameter	Single Shear One Rivet	No. of Rivets in One Row	Size of Seat Angle	Stiffener Angles: Size Outstanding Leg Listed First	Stiffener Angles: Bearing Value of Two Angles in Kips	Stiffener Angles: Gage of Angle	Capacity of Rivet Group in Kips: Two Stiff.	Capacity of Rivet Group in Kips: One Stiff.	Weight of Connection Lb.: Two Stiff.	Weight of Connection Lb.: One Stiff.
¾″	6.63	3	6 x 4 x ⅜	3½ x 3 x 5/16	51	1¾	40		29	
		4	6 x 4 x ⅜	3½ x 3 x 5/16	51	1¾	53		35	
		4	6 x 4 x ⅜	3½ x 4 x 5/16	51	2½	38		42	
		4	6 x 4 x ⅜	3½ x 5 x 5/16	51	3½	31		48	
		5	6 x 4 x ⅜	3½ x 3 x 7/16	71	1¾	66		47	
		5	6 x 4 x ⅜	3½ x 4 x 5/16	51	2½	51		49	
		5	6 x 4 x ⅜	3½ x 5 x 5/16	51	3½	43		56	
		6	6 x 4 x ⅜	3½ x 3 x ½	81	1¾	80	40	59	37
		6	6 x 4 x ⅜	3½ x 4 x 7/16	71	2½	65		66	
		6	6 x 4 x ⅜	3½ x 5 x ⅜	61	3½	56		70	
		7	6 x 4 x ⅜	3½ x 3 x 9/16	91	1¾	93	46	70	42
		7	6 x 4 x ⅜	3½ x 4 x ½	81	2½	79	39	78	48
		7	6 x 4 x ⅜	3½ x 5 x 7/16	71	3½	70		85	
⅞″	9.02	3	6 x 4 x ⅜	3½ x 3 x ⅜	61	1¾	54		35	
		4	6 x 4 x ⅜	3½ x 3 x 7/16	71	1¾	72	36	44	31
		4	6 x 4 x ⅜	3½ x 4 x 5/16	51	2½	50		47	
		4	6 x 4 x ⅜	3½ x 5 x 5/16	51	3½	42		53	
		5	6 x 4 x ⅜	3½ x 3 x 9/16	91	1¾	90	45	59	37
		5	6 x 4 x ⅜	3½ x 4 x 7/16	71	2½	69		63	
		5	6 x 4 x ⅜	3½ x 5 x ⅜	61	3½	59		67	
		6	6 x 6 x ⅜	5 x 3½ x 7/16	106	1¾	108	54	73	46
		6	6 x 6 x ⅜	4 x 4 x ½	95	2½	88	44	81	51
		6	6 x 6 x ⅜	4 x 6 x 7/16	83	3½	77	38	95	61
		7	6 x 6 x ⅜	5 x 3½ x ½	122	1¾	126	63	89	54
		7	6 x 6 x ⅜	4 x 4 x 9/16	106	2½	107	54	97	60
		7	6 x 6 x ⅜	4 x 6 x ½	95	3½	95	48	115	71
1″	11.78	3	6 x 4 x ⅜	3½ x 3½ x 7/16	71	2	71		43	
		3	6 x 4 x ⅜	3½ x 4 x ⅜	61	2½	44		45	
		4	6 x 4 x ⅜	3½ x 3½ x 9/16	91	2	94	47	58	39
		4	6 x 4 x ⅜	3½ x 4 x 7/16	71	2½	67		58	
		4	6 x 4 x ⅜	3½ x 5 x ⅜	61	3½	55		61	
		5	6 x 6 x ⅜	5 x 3½ x ½	122	2	118	59	74	47
		5	6 x 6 x ⅜	4 x 4 x ½	95	2½	91	45	76	50
		5	6 x 6 x ⅜	4 x 6 x 7/16	83	3½	77	38	88	58
		6	6 x 6 x ⅜	5 x 3½ x 9/16	137	2	141	71	91	56
		6	6 x 6 x ⅜	5 x 5 x ½	122	2½	115	58	101	62
		6	6 x 6 x ⅜	5 x 5 x 7/16	106	3½	100	50	98	62

Effective length of bearing assumed ½ inch less than length of outstanding leg.

Capacities are based on rivets in single shear. Rivet values should be investigated for bearing when seats connect to thin material or when seats on opposite sides of a carrying member have rivets in common.

Torsion on rivet groups is figured in accordance with the procedure outlined under Stiffened Beam Seats. For capacities between stiffener gages of 2½ and 3½ inches, interpolate.

For capacities under 35 kips unstiffened seat angles should be used.

Weight of connection includes top and seat angles, fillers, stiffeners and rivets, shown in sketch, and should be used for estimating purposes only. Length of top and seat angles assumed 4 inches greater than the distance between rivet lines, except for stiffeners with 6 inch leg for which the length is assumed as 12 inches.

ALLOWABLE UNIT STRESSES

COMPRESSION MEMBERS

KIPS PER SQUARE INCH

Under new A.I.S.C. Specification, slenderness ratio of a Main Compression Member may exceed 120 but not 200, provided it is not ordinarily subject to Shock or Vibratory load, and provided that its unit stress under full design loading shall not exceed the following fraction of that stipulated for its actual ratio of l/r: $1.6 - \frac{l}{200\,r}$

Main and Secondary Members l/r 1 to 120 inc. $f = 17000 - 0.485\left(\frac{l}{r}\right)^2$						Secondary Members l/r 121 to 240 inc. $f = \frac{18000}{1 + \frac{l^2}{18000\,r^2}}$				Main Members l/r 121 to 200 inc. $f = \frac{18000}{1 + \frac{l^2}{18000\,r^2}} \times \left(1.6 - \frac{l}{200\,r}\right)$			
$\frac{l}{r}$	.0	.5	$\frac{l}{r}$	.0	.5	$\frac{l}{r}$	.0	$\frac{l}{r}$	.0	$\frac{l}{r}$	.0	$\frac{l}{r}$	.0
1	17.00	17.00	61	15.20	15.17	121	9.93	181	6.38	121	9.88	181	4.43
2	17.00	17.00	62	15.14	15.11	122	9.85	182	6.34	122	9.75	182	4.37
3	17.00	16.99	63	15.08	15.05	123	9.78	183	6.29	123	9.63	183	4.31
4	16.99	16.99	64	15.01	14.98	124	9.71	184	6.25	124	9.52	184	4.25
5	16.99	16.99	65	14.95	14.92	125	9.64	185	6.20	125	9.40	185	4.19
6	16.98	16.98	66	14.89	14.86	126	9.56	186	6.16	126	9.27	186	4.13
7	16.98	16.97	67	14.82	14.79	127	9.49	187	6.12	127	9.16	187	4.07
8	16.97	16.97	68	14.76	14.73	128	9.42	188	6.07	128	9.04	188	4.01
9	16.96	16.96	69	14.69	14.66	129	9.35	189	6.03	129	8.93	189	3.95
10	16.95	16.95	70	14.62	14.59	130	9.28	190	5.99	130	8.82	190	3.89
11	16.94	16.94	71	14.56	14.53	131	9.22	191	5.95	131	8.71	191	3.84
12	16.93	16.92	72	14.49	14.45	132	9.15	192	5.91	132	8.60	192	3.78
13	16.92	16.91	73	14.42	14.39	133	9.08	193	5.86	133	8.49	193	3.72
14	16.91	16.90	74	14.34	14.31	134	9.01	194	5.82	134	8.38	194	3.67
15	16.89	16.88	75	14.27	14.24	135	8.94	195	5.78	135	8.27	195	3.61
16	16.88	16.87	76	14.20	14.16	136	8.88	196	5.74	136	8.17	196	3.56
17	16.86	16.85	77	14.12	14.08	137	8.81	197	5.70	137	8.06	197	3.51
18	16.84	16.83	78	14.05	14.01	138	8.75	198	5.66	138	7.96	198	3.45
19	16.83	16.82	79	13.97	13.94	139	8.68	199	5.62	139	7.86	199	3.40
20	16.81	16.80	80	13.90	13.86	140	8.62	200	5.59	140	7.76	200	3.35
21	16.79	16.78	81	13.82	13.78	141	8.55	201	5.55	141	7.65		
22	16.77	16.76	82	13.74	13.70	142	8.49	202	5.51	142	7.56		
23	16.74	16.73	83	13.66	13.62	143	8.43	203	5.47	143	7.46		
24	16.72	16.71	84	13.58	13.54	144	8.36	204	5.44	144	7.36		
25	16.70	16.69	85	13.50	13.46	145	8.30	205	5.40	145	7.26		
26	16.67	16.66	86	13.41	13.37	146	8.24	206	5.36	146	7.17		
27	16.65	16.64	87	13.33	13.28	147	8.18	207	5.33	147	7.08		
28	16.62	16.61	88	13.24	13.20	148	8.12	208	5.29	148	6.98		
29	16.59	16.58	89	13.16	13.11	149	8.06	209	5.25	149	6.89		
30	16.56	16.55	90	13.07	13.03	150	8.00	210	5.22	150	6.80		
31	16.53	16.52	91	12.98	12.94	151	7.94	211	5.18	151	6.71		
32	16.50	16.49	92	12.90	12.85	152	7.88	212	5.15	152	6.62		
33	16.47	16.46	93	12.81	12.76	153	7.82	213	5.11	153	6.53		
34	16.44	16.43	94	12.72	12.67	154	7.77	214	5.08	154	6.45		
35	16.41	16.39	95	12.62	12.58	155	7.71	215	5.05	155	6.36		
36	16.37	16.36	96	12.53	12.49	156	7.65	216	5.01	156	6.27		
37	16.34	16.32	97	12.44	12.39	157	7.60	217	4.98	157	6.19		
38	16.30	16.29	98	12.34	12.29	158	7.54	218	4.95	158	6.11		
39	16.26	16.25	99	12.25	12.20	159	7.49	219	4.91	159	6.03		
40	16.22	16.21	100	12.15	12.10	160	7.43	220	4.88	160	5.94		
41	16.19	16.17	101	12.05	12.00	161	7.38	221	4.85	161	5.87		
42	16.14	16.12	102	11.95	11.90	162	7.32	222	4.82	162	5.78		
43	16.10	16.08	103	11.86	11.80	163	7.27	223	4.78	163	5.71		
44	16.06	16.04	104	11.75	11.71	164	7.22	224	4.75	164	5.63		
45	16.02	16.00	105	11.65	11.60	165	7.16	225	4.72	165	5.33		
46	15.97	15.95	106	11.55	11.50	166	7.11	226	4.69	166	5.47		
47	15.93	15.91	107	11.45	11.40	167	7.06	227	4.66	167	5.40		
48	15.88	15.86	108	11.34	11.30	168	7.01	228	4.63	168	5.33		
49	15.84	15.82	109	11.24	11.19	169	6.96	229	4.60	169	5.25		
50	15.79	15.76	110	11.13	11.08	170	6.91	230	4.57	170	5.18		
51	15.74	15.72	111	11.02	10.97	171	6.86	231	4.54	171	5.11		
52	15.69	15.66	112	10.92	10.86	172	6.81	232	4.51	172	5.04		
53	15.64	15.61	113	10.81	10.75	173	6.76	233	4.48	173	4.97		
54	15.59	15.56	114	10.70	10.64	174	6.71	234	4.45	174	4.90		
55	15.53	15.51	115	10.59	10.53	175	6.66	235	4.43	175	4.83		
56	15.48	15.45	116	10.47	10.41	176	6.62	236	4.40	176	4.77		
57	15.42	15.39	117	10.36	10.31	177	6.57	237	4.37	177	4.70		
58	15.37	15.34	118	10.25	10.19	178	6.52	238	4.34	178	4.63		
59	15.31	15.28	119	10.13	10.08	179	6.48	239	4.31	179	4.57		
60	15.25	15.23	120	10.02	9.96	180	6.43	240	4.29	180	4.50		

STEEL COLUMNS

The Specification of the American Institute of Steel Construction now permits l/r ratios exceeding 120 in Main, or Primary, Compression members, when a proper reduction formula is used. The various formulae are:

Columns with l/r values from 0 to 120, main or secondary members:

$$f = 17{,}000 - 0.485\,\frac{l^2}{r^2} \qquad \text{(p. s. i.)}$$

Columns with l/r values greater than 120:

1. Bracing and secondary members:

$$f = \frac{18000}{1 + \dfrac{l^2}{18000\,r^2}}$$

2. Main members:

$$f = \frac{18000}{1 + \dfrac{l^2}{18000\,r^2}} \times \left(1.6 - \frac{l/r}{200}\right)$$

The A.I.S.C. Specification, in treating eccentric loads on columns, has established an equation in which the quantity

$$\frac{f_a}{F_a} + \frac{f_b}{F_b} \quad \text{shall not exceed unity.}$$

See A. I. S. C. Specifications for nomenclature.

ECCENTRIC LOADING

When beams or girders frame into column webs the eccentricity effect is usually negligible; when they connect to the column flanges their effect should be investigated. In the Column Tables on pages 147 to 149 will be found two coefficients, K_c and K_e. Coefficient K_c gives the amount of equivalent concentric load that must be carried by the column when the beam is connected directly to the column flange; K_e gives the additional amount required per inch of distance, e_1, from the column flange to the point of eccentric load, as when a bracket is used. These coefficients are not to be used when framing is to web of column.

Example:

Assume a 14" Wide Flange column carrying a direct load of 300 kips, with an eccentric load of 50 kips applied 18 inches from the strong axis of the column. Unbraced column length is 12 feet. $l/r = (12 \times 12) \div 3.72 = 39$ (3.72 is an assumed least radius of gyration). For $l/r = 39$, allowable fiber stress is 16.26. Assuming 14" @ 103# section, area equals 30.26 sq. in.

Assuming a 14" @ 103# column, $K_c = 1.32$ and $K_e = .185$. The distance from face of flange to load is $18.0 - 7.12 = 10.88$. The equivalent concentric load, P_c, from the equation $P_c = P_e[K_c + (e_1K_e)]$ is

$$P_c = 50 \times [1.32 + (10.88 \times .185)] = 166.5$$

The load for which column must be designed is $P + P_e + P_c = 300 + 50 + 166.5 = 516.5$.

Checking for $\dfrac{f_a}{F_a} + \dfrac{f_b}{F_b}$ the result is $\dfrac{11.57}{16.26} + \dfrac{5.50}{20.0} = 0.987$, which is OK.

GENERAL FORMULAE

Case 1. Column with Eccentric Load at Top:

$$A = \frac{P + P_e}{F} + \frac{P_e ce}{F_b r^2}$$

Case 2. Column with Eccentric Load Below Top:

$$A = \frac{P}{F} + \frac{P_e}{F_e} + \frac{P_e cek}{lF_b r^2}$$

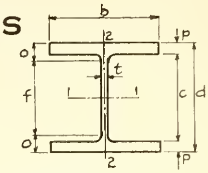
See Page 146 for explanation of use of coefficients K_c and K_e, for columns with bending produced by eccentric loads.

MISCELLANEOUS ROLLED COLUMNS

PROPERTIES AND DIMENSIONS

ALLOWABLE CONCENTRIC LOAD, IN KIPS

1946 A.I.S.C. SPECIFICATIONS



Heavy line denotes $l/r = 120$

SIZE	TYPE	WEIGHT PER FT.	AREA SQ. IN.	Dimensions						Axis 1-1		Axis 2-2		BENDING FACTORS		Effective Length, in Feet											
				d	b	p	t	f	o	I_1	r_1	I_2	r_2	K_c	K_e	6	7	8	9	10	12	14	16	18	20	22	24
3″	I	5.7	1.64	3	2⅜	¼	3/16	1⅞	9/16	2.5	1.23	0.46	0.53	1.50	1.000	13	10	7									
		7.5	2.17	3	2½	¼	⅜	1⅞	9/16	2.9	1.15	0.59	0.52	1.70	1.130	17	13	9									
4″	I	7.7	2.21	4	2⅝	5/16	3/16	2¾	⅝	6.0	1.64	0.77	0.59	1.49	.743	22	17	13	10								
		9.5	2.76	4	2¾	5/16	5/16	2¾	⅝	6.7	1.56	0.91	0.58	1.64	.822	26	20	15	11								
	S	10.	2.93	4	4	¼	¼	2⅞	9/16	8.31	1.68	2.74	0.97	1.41	.704	42	39	36	32	27	20	14	10				
		13.	3.82	4	4⅛	⅝	¼	2½	¾	11.3	1.72	3.76	0.99	1.46	.701	55	52	48	43	37	27	19	14				
	H	13	3.82	4	4	⅝	¼	2½	¾	10.4	1.65	3.4	0.94	1.47	.735	54	50	46	40	34	25	17					
5″	I	10.0	2.87	5	3	5/16	¼	3⅝	11/16	12.1	2.05	1.2	0.65	1.49	.595	32	26	20	15	12							
		14.75	4.29	5	3¼	5/16	½	3⅝	11/16	15.0	1.87	1.7	0.63	1.79	.715	46	36	28	22	17							
	S	16.0	4.70	5	5	⅜	¼	3 11/16	⅝	21.3	2.13	7.51	1.26	1.38	.551	72	70	67	63	59	50	39	30	23	18		
		18.5	5.45	5⅛	5	7/16	¼	3 11/16	11/16	25.4	2.16	8.89	1.28	1.40	.548	84	81	78	74	69	59	47	37	28	21		
	H	18.9	5.47	5	5	7/16	5/16	3⅜	13/16	23.8	2.08	7.8	1.20	1.44	.578	83	80	76	72	66	55	42	32	25	19		
6″	J	8.5	2.50	5⅞	4	3/16	3/16	5	7/16	14.8	2.43	1.89	0.87	1.44	.494	34	31	28	24	20	14	9					
	LB	12.0	3.53	6	4	¼	¼	4⅞	9/16	21.7	2.48	2.89	0.90	1.46	.488	49	45	41	35	29	20	14					
		16.0	4.72	6¼	4	⅜	¼	4⅞	11/16	31.7	2.59	4.32	0.96	1.46	.466	67	63	57	51	44	32	22	15				
	I	12.5	3.61	6	3⅜	5/16	¼	4½	¾	21.8	2.46	1.8	0.72	1.49	.496	44	38	31	25	20	12						
		17.25	5.02	6	3⅜	⅜	½	4½	¾	26.0	2.28	2.3	0.68	1.73	.577	58	48	38	31	24							
	S	15.5	4.59	6	6	¼	¼	4⅞	9/16	30.3	2.56	9.69	1.45	1.37	.458	73	71	69	66	63	56	48	39	31	25	20	15
		20.0	5.88	6¼	6	⅜	¼	4⅞	11/16	41.7	2.66	13.3	1.50	1.37	.440	94	91	89	85	82	74	64	53	43	35	28	22
		25.0	7.35	6⅜	6	½	5/16	4⅞	¾	53.5	2.69	17.1	1.52	1.40	.439	117	114	111	107	103	93	82	68	55	45	36	28
	H	20.0	5.86	6	6	⅜	⅜	4 7/16	¾	38.8	2.57	11.4	1.39	1.36	.455	92	89	86	82	78	69	58	46	37	29	22	
		25.0	7.33	6	6	½	½	4¼	⅞	47.0	2.53	14.9	1.43	1.41	.469	116	112	108	104	100	89	76	61	49	39	31	
7″	I	15.3	4.43	7	3⅝	⅜	¼	5⅜	13/16	36.2	2.86	2.7	0.78	1.50	.428	57	51	43	35	28	18						
		20.0	5.83	7	3⅞	⅜	7/16	5⅜	13/16	41.9	2.68	3.1	0.74	1.71	.487	72	63	51	42	34	21						
8″	J	10.0	2.95	7⅞	4	3/16	3/16	6⅞	½	30.8	3.23	1.99	0.82	2.64	.669	39	35	30	26	21	14						
	LB	13.0	3.83	8	4	¼	¼	6⅞	9/16	39.5	3.21	2.62	0.83	1.55	.388	51	46	40	34	28	19						
		15.0	4.43	8⅛	4	5/16	¼	6⅞	⅝	48.0	3.29	3.30	0.86	1.50	.375	60	55	49	42	34	24	16					
	WF	17	5.00	8	5¼	5/16	¼	6¾	⅝	56.4	3.36	6.72	1.16	1.42	.355	76	72	68	64	59	48	37	28	21			
		20	5.88	8⅛	5¼	⅜	¼	6¾	11/16	69.2	3.43	8.50	1.20	1.41	.346	90	86	82	77	71	59	46	35	26	20		
	I	18.4	5.34	8	4	7/16	5/16	6¼	⅞	56.9	3.26	3.8	0.84	1.51	.376	72	65	57	48	40	27	18					
		23.0	6.71	8	4⅛	7/16	7/16	6¼	⅞	64.2	3.09	4.4	0.81	1.68	.419	88	79	69	57	47	31						
	H	34.3	10.0	8	8	7/16	7/16	6¼	⅞	115.5	3.40	35.1	1.87	1.38	.346	163	160	157	154	150	141	131	120	104	90	76	65
10″	J	11.5	3.39	9⅞	4	3/16	3/16	8⅞	½	51.9	3.92	2.01	0.77	1.59	.321	43	38	33	26	21	14						
	LB	15.0	4.40	10	4	¼	¼	8⅞	9/16	68.8	3.95	2.79	0.80	1.59	.319	57	51	44	36	30	20						
		17.0	4.98	10⅛	4	5/16	¼	8⅞	⅝	81.8	4.05	3.45	0.83	1.56	.307	66	60	53	44	37	25						
		19.0	5.61	10¼	4	⅜	¼	8⅞	11/16	96.2	4.14	4.19	0.86	1.53	.298	76	70	61	52	43	30	20					
	WF	21	6.19	9⅞	5¾	5/16	¼	8½	11/16	106.3	4.14	9.7	1.25	1.41	.287	95	92	87	83	77	65	52	40	31	23		
		25	7.35	10⅛	5¾	7/16	¼	8½	13/16	133.2	4.26	12.7	1.31	1.41	.278	114	110	106	101	95	82	66	53	41	32		
		29	8.53	10¼	5¾	½	5/16	8½	⅞	157.3	4.29	15.2	1.34	1.42	.274	133	129	124	118	111	98	80	64	50	39	30	
	I	25.4	7.38	10	4⅝	½	5/16	8	1	122.1	4.07	6.9	0.97	1.51	.302	106	98	90	81	70	51	37	26				
		35.0	10.22	10	5	½	⅝	8	1	145.8	3.78	8.5	0.91	1.75	.350	143	131	119	105	88	62	43					
12″	J	14.0	4.14	11⅞	4	¼	3/16	10¾	9/16	88.2	4.61	2.25	0.74	1.67	.280	51	45	37	30	24	15						
	LB	16.5	4.86	12	4	¼	¼	10¾	⅝	105.3	4.65	2.79	0.76	1.67	.278	61	54	45	37	30	19						
		19.0	5.62	12⅛	4	⅜	¼	10¾	11/16	130.1	4.81	3.67	0.81	1.60	.263	74	66	58	48	39	26						
		22.0	6.47	12¼	4	7/16	¼	10¾	¾	155.7	4.91	4.55	0.84	1.57	.256	87	79	69	58	48	33						
	WF	27	7.97	12	6½	⅜	¼	10⅜	13/16	204.1	5.06	16.6	1.44	1.40	.234	126	122	118	113	109	97	82	68	54	43	34	27
		31	9.12	12⅛	6½	7/16	¼	10⅜	⅞	238.4	5.11	19.8	1.47	1.40	.231	144	140	136	131	125	112	98	79	65	52	42	32
		36	10.59	12¼	6⅝	9/16	5/16	10⅜	15/16	280.8	5.15	23.7	1.50	1.41	.230	169	164	159	153	147	133	116	96	78	63	50	40
	I	31.8	9.26	12	5	9/16	⅜	9¾	1⅛	215.8	4.83	9.5	1.01	1.54	.257	135	126	117	106	95	69	51	36				
		35.0	10.20	12	5⅛	9/16	7/16	9¾	1⅛	227.0	4.72	10.0	0.99	1.62	.269	147	138	127	114	100	73	53	37				

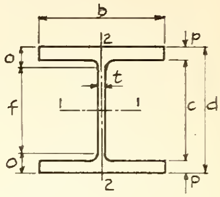
See Page 146 for explanation of use of coefficients K_c and K_e, for columns with bending produced by eccentric loads.

WIDE FLANGE COLUMNS

PROPERTIES AND DIMENSIONS

ALLOWABLE CONCENTRIC LOAD, IN KIPS

1946 A. I. S. C. SPECIFICATIONS



* Column Core Section

Heavy line denotes l/r = 120

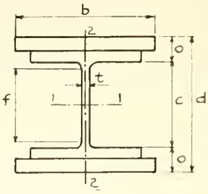
SIZE	WEIGHT	AREA	Dimensions							Axis 1-1		Axis 2-2		BENDING FACTORS		Effective Length, in Feet											
			d	b	p	t	c	f	o	I	r_1	I	r_2	Kc	Ke	10	11	12	14	16	18	20	22	24	26	28	30
8″	24	7.06	7⅞	6½	⅜	¼	7⅛	6⅜	13/16	83	3.42	18	1.61	1.34	.339	101	97	93	83	71	59	49	40	32	26		
	28	8.23	8	6½	7/16	5/16	7⅛	6⅜	13/16	98	3.45	22	1.62	1.36	.339	118	114	108	96	83	69	58	47	39	31		
	31	9.12	8	8	7/16	5/16	7⅛	6⅜	13/16	110	3.47	37	2.01	1.33	.332	139	136	132	124	115	104	92	79	68	57	49	42
	35	10.30	8⅛	8	½	5/16	7⅛	6⅜	⅞	127	3.50	43	2.03	1.34	.331	158	154	150	141	131	119	105	91	78	67	57	48
	40	11.76	8¼	8⅛	9/16	⅜	7⅛	6⅜	15/16	146	3.53	49	2.04	1.36	.330	180	176	172	161	149	136	121	105	89	77	65	56
	48	14.11	8½	8⅛	11/16	7/16	7⅛	6⅜	1 1/16	184	3.61	61	2.08	1.38	.329	217	212	207	195	182	166	149	129	112	96	82	70
	58	17.06	8¾	8¼	13/16	½	7⅛	6⅜	1 3/16	227	3.65	75	2.10	1.44	.328	263	257	251	237	221	202	182	159	137	118	102	87
	67	19.70	9	8¼	15/16	9/16	7⅛	6⅜	1 5/16	272	3.71	87	2.12	1.47	.327	304	298	291	275	256	236	212	186	161	139	120	102
10″	33	9.71	9¾	8	7/16	5/16	8⅞	7⅞	15/16	171	4.20	37	1.94	1.35	.277	147	143	139	130	119	107	92	79	68	57	48	40
	39	11.48	10	8	½	5/16	8⅞	7⅞	1 1/16	210	4.27	45	1.98	1.36	.274	175	170	166	155	143	129	113	97	83	71	60	50
	45	13.24	10⅛	8	⅝	⅜	8⅞	7⅞	1⅛	249	4.33	53	2.00	1.37	.270	202	197	192	180	166	150	133	114	98	84	71	60
	49	14.40	10	10	9/16	⅜	8⅞	7⅞	1 1/16	273	4.35	93	2.54	1.32	.264	229	226	222	214	205	194	182	169	155	139	123	109
	54	15.88	10⅛	10	⅝	⅜	8⅞	7⅞	1⅛	306	4.39	104	2.56	1.33	.263	253	250	246	237	227	215	202	188	172	156	138	122
	60	17.66	10¼	10⅛	11/16	7/16	8⅞	7⅞	1 3/16	344	4.41	117	2.57	1.35	.263	282	278	274	264	252	240	226	210	193	174	154	127
	66	19.41	10⅜	10⅛	¾	7/16	8⅞	7⅞	1¼	383	4.44	129	2.58	1.37	.263	309	305	301	290	278	264	249	231	213	192	171	152
	72	21.18	10½	10⅛	13/16	½	8⅞	7⅞	1	421	4.46	142	2.59	1.38	.262	338	333	328	317	303	289	272	253	233	211	187	167
	77	22.67	10⅝	10¼	⅞	9/16	8⅞	7⅞	1⅜	457	4.49	153	2.60	1.40	.262	362	357	352	340	326	310	292	272	250	227	202	180
	89	26.19	10⅞	10¼	1	⅝	8⅞	7⅞	1½	542	4.55	181	2.63	1.43	.262	419	413	407	394	378	360	340	317	293	267	237	212
	100	29.43	11⅛	10⅜	1⅛	11/16	8⅞	7⅞	1⅝	625	4.61	207	2.65	1.45	.261	471	465	458	443	425	406	383	359	332	302	270	241
	112	32.92	11⅜	10⅜	1¼	¾	8⅞	7⅞	1¾	719	4.67	235	2.67	1.48	.261	528	521	513	496	477	455	431	403	374	341	306	273
12″	40	11.77	12	8	½	3/16	10⅞	9¾	1⅛	310	5.13	44	1.94	1.35	.227	178	174	169	157	144	129	113	96	81	69	58	49
	45	13.24	12	8	9/16	3/16	10⅞	9¾	1 3/16	351	5.15	50	1.94	1.37	.227	200	195	190	177	162	145	127	108	92	78	65	55
	50	14.71	12¼	8⅛	⅝	3/16	10⅞	9¾	1¼	395	5.18	56	1.96	1.38	.227	223	218	212	198	182	163	142	122	104	88	75	63
	53	15.59	12	10	9/16	3/16	10⅞	9¾	1 3/16	426	5.23	96	2.48	1.33	.220	248	244	240	230	220	208	194	179	163	145	128	113
	58	17.06	12¼	10	⅝	3/16	10⅞	9¾	1¼	476	5.28	107	2.51	1.34	.220	271	267	263	253	241	229	214	198	181	161	143	126
	65	19.11	12⅛	12	⅝	3/16	10⅞	9¾	1 3/16	533	5.28	175	3.02	1.32	.217	310	307	304	296	288	278	266	254	241	226	210	193
	72	21.16	12¼	12	11/16	¼	10⅞	9¾	1¼	597	5.31	195	3.04	1.33	.217	344	341	337	328	319	308	296	282	268	252	234	216
	79	23.22	12⅜	12⅛	¾	¼	10⅞	9¾	1 5/16	663	5.34	216	3.05	1.34	.217	378	374	370	361	350	338	325	310	294	277	258	238
	85	24.98	12½	12⅛	13/16	¼	10⅞	9¾	1⅜	723	5.38	236	3.07	1.35	.216	406	402	398	388	377	365	351	335	318	300	280	258
	92	27.06	12⅝	12⅛	⅞	5/16	10⅞	9¾	1 7/16	789	5.40	256	3.08	1.36	.216	440	436	431	421	409	395	380	364	346	326	304	281
	99	29.09	12¾	12¼	15/16	5/16	10⅞	9¾	1½	859	5.43	278	3.09	1.38	.216	473	469	464	453	440	426	410	392	372	351	328	303
	106	31.19	12⅞	12¼	1	5/16	10⅞	9¾	1 9/16	931	5.46	301	3.11	1.39	.215	508	503	498	486	473	457	440	421	400	378	354	327
	120	35.31	13⅛	12⅜	1⅛	⅜	10⅞	9¾	1 11/16	1072	5.51	345	3.13	1.42	.215	575	570	564	551	536	519	500	478	455	430	403	374
	133	39.11	13⅜	12⅜	1¼	⅜	10⅞	9¾	1 13/16	1221	5.59	390	3.16	1.43	.215	638	632	626	611	595	576	555	532	507	480	451	419
	161	47.38	13⅞	12½	1½	7/16	10⅞	9¾	2 1/16	1542	5.70	486	3.20	1.48	.214	773	766	759	742	723	701	676	649	619	587	552	515
	190	55.86	14⅜	12⅝	1¾	9/16	10⅞	9¾	2 5/16	1893	5.82	590	3.25	1.53	.212	913	905	896	877	855	830	802	771	737	700	660	617
14″	43	12.65	13⅝	8	½	3/16	12⅝	11⅜	1⅛	429	5.82	45	1.89	1.38	.202	190	185	179	166	152	135	116	98	83	70	59	49
	48	14.11	13¾	8	9/16	3/16	12⅝	11⅜	1 3/16	485	5.86	51	1.91	1.39	.201	213	207	201	187	171	152	131	112	95	80	67	56
	53	15.59	14	8	11/16	3/16	12⅝	11⅜	1¼	542	5.90	58	1.92	1.40	.201	235	229	222	207	190	169	146	125	106	90	75	63
	61	17.94	13⅞	10	⅝	3/16	12⅝	11⅜	1¼	642	5.98	107	2.45	1.35	.194	284	280	275	264	252	238	222	204	185	164	144	127
	68	20.00	14	10	11/16	¼	12⅝	11⅜	1 5/16	724	6.02	121	2.46	1.36	.194	317	312	307	295	281	265	248	228	207	184	162	142
	74	21.76	14¼	10⅛	13/16	¼	12⅝	11⅜	1⅜	797	6.05	134	2.48	1.37	.194	345	340	334	321	307	290	271	250	228	202	179	157
	78	22.94	14	12	11/16	¼	12⅝	11⅜	1 5/16	851	6.09	207	3.00	1.33	.190	372	368	364	355	344	332	319	304	288	270	250	230
	84	24.71	14⅛	12	¾	¼	12⅝	11⅜	1⅜	928	6.13	226	3.02	1.34	.189	401	397	393	383	372	359	345	329	311	292	272	250
	87	25.56	14	14½	11/16	7/16	12⅝	11⅜	1	967	6.15	350	3.70	1.30	.185	422	419	416	409	401	392	382	372	360	346	332	317
	95	27.94	14⅛	14½	¾	½	12⅝	11⅜	1⅜	1064	6.17	384	3.71	1.31	.185	461	458	455	447	439	429	418	406	393	379	364	347
	103	30.26	14¼	14⅝	13/16	½	12⅝	11⅜	1 7/16	1166	6.21	420	3.72	1.32	.185	499	496	493	485	475	465	453	441	427	411	395	377
	111	32.65	14⅜	14⅝	⅞	9/16	12⅝	11⅜	1½	1267	6.23	455	3.73	1.35	.185	539	535	531	523	513	502	490	476	461	444	426	408
	119	34.99	14½	14⅝	15/16	9/16	12⅝	11⅜	1 9/16	1373	6.26	492	3.75	1.34	.185	578	574	570	561	551	539	525	511	495	477	459	438
	127	37.33	14⅝	14¾	1	⅝	12⅝	11⅜	1⅝	1477	6.29	528	3.76	1.35	.185	616	612	608	598	587	575	561	545	528	510	490	469
	136	39.98	14¾	14¾	1 1/16	11/16	12⅝	11⅜	1 11/16	1593	6.31	568	3.77	1.36	.185	660	656	651	641	629	616	601	585	567	547	526	503
	*320	94.12	16¾	16¾	2 1/16	1⅞	12⅝	11⅜	2 11/16	4142	6.63	1635	4.17	1.61	.191	1562	1554	1546	1526	1503	1478	1449	1417	1382	1345	1303	1260
	142	41.85	14¾	15½	1 1/16	11/16	12⅝	11⅜	1 11/16	1672	6.32	660	3.97	1.36	.185	693	689	685	675	664	652	638	622	605	586	566	544
	150	44.08	14⅞	15½	1⅛	11/16	12⅝	11⅜	1¾	1787	6.37	703	3.99	1.36	.183	730	726	722	712	700	687	672	656	638	619	598	575
	158	46.47	15	15½	1 3/16	¾	12⅝	11⅜	1 13/16	1901	6.40	745	4.00	1.37	.183	770	766	761	750	738	724	709	692	673	653	631	607
	167	49.09	15⅛	15⅝	1¼	13/16	12⅝	11⅜	1⅞	2021	6.42	790	4.01	1.38	.183	813	809	804	793	780	765	749	731	712	690	667	643
	176	51.73	15¼	15⅝	1 5/16	13/16	12⅝	11⅜	1 15/16	2150	6.45	838	4.02	1.39	.183	857	852	847	836	822	807	790	771	751	728	704	678
	184	54.07	15⅜	15⅝	1⅜	⅞	12⅝	11⅜	2	2275	6.49	883	4.04	1.40	.183	896	891	886	874	860	844	827	807	786	763	738	711
	193	56.73	15½	15¾	1 7/16	⅞	12⅝	11⅜	2 1/16	2402	6.51	930	4.05	1.42	.183	940	935	930	917	903	886	868	848	825	801	775	747
	202	59.39	15⅝	15¾	1½	15/16	12⅝	11⅜	2⅛	2539	6.54	980	4.06	1.43	.183	984	979	973	960	945	928	909	888	865	840	812	783
	211	62.07	15¾	15¾	1 9/16	1	12⅝	11⅜	2 3/16	2671	6.56	1029	4.07	1.44	.183	1029	1024	1018	1004	988	971	951	928	904	878	850	819
	219	64.36	15⅞	15⅞	1⅝	1	12⅝	11⅜	2¼	2798	6.59	1073	4.08	1.45	.183	1067	1061	1055	1041	1025	1007	986	963	938	911	882	851
	228	67.06	16	15⅞	1 11/16	1 1/16	12⅝	11⅜	2 5/16	2942	6.62	1125	4.10	1.46	.183	1112	1106	1100	1086	1069	1050	1029	1005	980	952	927	889
	237	69.69	16⅛	15⅞	1¾	1⅛	12⅝	11⅜	2⅜	3081	6.65	1175	4.11	1.47	.182	1156	1150	1143	1128	1111	1091	1070	1045	1019	990	959	925
	246	72.33	16¼	16	1 13/16	1⅛	12⅝	11⅜	2 7/16	3229	6.68	1227	4.12	1.48	.182	1200	1194	1187	1171	1154	1133	1110	1085	1058	1029	966	962
	264	77.63	16½	16	1 15/16	1¼	12⅝	11⅜	2 9/16	3526	6.74	1331	4.14	1.50	.182	1288	1281	1274	1258	1239	1217	1193	1166	1137	1106	1071	1035
	287	84.37	16¾	16⅛	2 1/16	1 5/16	12⅝	11⅜	2 11/16	3912	6.81	1467	4.17	1.52	.181	1400	1393	1386	1368	1348	1325	1299	1270	1239	1205	1168	1130
	314	92.30	17¼	16¼	2 5/16	1 7/16	12⅝	11⅜	2⅞	4399	6.90	1631	4.20	1.55	.181	1533	1525	1516	1497	1476	1450	1423	1392	1359	1322	1283	1240
	*320	94.12	16¾	16¾	2 1/16	1⅞	12⅝	11⅜	2 11/16	4142	6.63	1635	4.17	1.61	.191	1562	1554	1546	1526	1503	1478	1449	1417	1382	1345	1303	1260
	342	100.59	17½	16⅜	2 7/16	1 9/16	12⅝	11⅜	3 1/16	4912	6.99	1807	4.24	1.58	.180	1671	1663	1654	1633	1610	1584	1554	1521	1485	1446	1404	1358
	370	108.78	18	16½	2 11/16	1 11/16	12⅝	11⅜	3¼	5454	7.08	1986	4.27	1.60	.179	1808	1799	1789	1768	1742	1714	1683	1648	1610	1567	1522	1474
	398	116.98	18¼	16⅝	2 13/16	1 13/16	12⅝	11⅜	3 7/16	6014	7.17	2170	4.31	1.63	.178	1945	1936	1925	1902	1876	1846	1813	1775	1736	1691	1643	1593
	426	125.25	18¾	16¾	3 1/16	1⅞	12⅝	11⅜	3⅝	6610	7.26	2360	4.34	1.66	.177	2083	2073	2062	2038	2011	1979	1944	1905	1862	1815	1765	1711

See Page 146 for explanation of use of coefficients K_c and K_e, for columns with bending produced by eccentric loads.

COVER-PLATED COLUMNS

PROPERTIES AND DIMENSIONS

ALLOWABLE CONCENTRIC LOAD, IN KIPS



12" @ 65 LBS. WF CORE

COL. CORE	COVER PLATES		TOTAL WEIGHT	TOTAL AREA	Axis 1-1		Axis 2-2		Dimensions						BENDING FACTORS		Effective Length, Feet											
	W	T			I_1	r_1	I_2	r_2	t	d	b	c	f	o	K_c	K_e	10	12	14	16	18	20	22	24	26	28	30	32
12" @ 65# WF	14	1/2	112.6	33.11	1101	5.76	403	3.50	3/8	13 1/8	14	10 7/8	9 3/4	1 11/16	1.65	1.97	545	535	525	515	502	485	470	455	435	415	394	373
	14	5/8	124.6	36.61	1245	5.84	460	3.54	3/8	13 5/8	14	10 7/8	9 3/4	1 13/16	1.65	1.97	602	593	581	570	557	540	523	506	485	463	440	416
	14	3/4	136.4	40.11	1404	5.92	518	3.59	3/8	13 5/8	14	10 7/8	9 3/4	1 15/16	1.65	1.95	660	651	640	625	612	594	576	557	534	515	485	460
	14	7/8	148.4	43.61	1569	6.00	575	3.63	3/8	13 7/8	14	10 7/8	9 3/4	2 1/16	1.66	1.93	718	707	696	682	665	649	629	608	585	559	534	504
	14	1	160.2	47.11	1741	6.08	632	3.66	3/8	14 1/8	14	10 7/8	9 3/4	2 3/16	1.66	1.91	775	766	753	737	722	702	683	658	636	608	582	550
	14	1 1/8	172.2	50.61	1929	6.17	689	3.69	3/8	14 3/8	14	10 7/8	9 3/4	2 5/16	1.67	1.89	833	823	809	795	778	757	736	711	687	658	630	595
	14	1 1/4	184.0	54.11	2102	6.23	746	3.72	3/8	14 5/8	14	10 7/8	9 3/4	2 7/16	1.68	1.87	893	880	867	849	832	809	788	765	735	707	679	642
	16	1	173.8	51.11	1913	6.11	857	4.09	3/8	14 1/8	16	10 7/8	9 3/4	2 3/16	1.49	1.88	848	840	838	815	800	784	765	748	727	703	677	651
	16	1 1/8	187.4	55.11	2117	6.20	943	4.13	3/8	14 3/8	16	10 7/8	9 3/4	2 5/16	1.50	1.87	914	905	892	879	865	848	827	807	783	763	735	706
	16	1 1/4	201.0	59.11	2326	6.27	1027	4.16	3/8	14 5/8	16	10 7/8	9 3/4	2 7/16	1.50	1.86	980	970	960	943	927	908	892	868	843	818	792	762
	16	1 3/8	214.6	63.11	2544	6.35	1113	4.20	3/8	14 7/8	16	10 7/8	9 3/4	2 9/16	1.51	1.85	1044	1038	1023	1008	995	975	952	927	901	878	847	819
	16	1 1/2	228.2	67.11	2769	6.42	1199	4.23	3/8	15 1/8	16	10 7/8	9 3/4	2 11/16	1.52	1.83	1118	1104	1090	1076	1058	1036	1017	990	96[illegible]	938	907	872
	16	1 5/8	241.8	71.11	3001	6.50	1284	4.25	3/8	15 3/8	16	10 7/8	9 3/4	2 13/16	1.53	1.82	1183	1170	1154	1140	1120	1098	1077	1050	1020	994	965	930
	16	1 3/4	255.4	75.11	3241	6.57	1369	4.27	3/8	15 5/8	16	10 7/8	9 3/4	2 15/16	1.54	1.81	1249	1234	1220	1202	1182	1160	1138	1114	1083	1049	1019	980
	16	1 7/8	269.0	79.11	3489	6.65	1455	4.29	3/8	15 7/8	16	10 7/8	9 3/4	3 1/16	1.55	1.80	1315	1300	1286	1270	1250	1223	1202	1173	1145	1112	1072	1041
	16	2	282.6	83.11	3745	6.70	1540	4.30	3/8	16 1/8	16	10 7/8	9 3/4	3 3/16	1.56	1.79	1380	1369	1350	1333	1310	1285	1261	1232	1203	1169	1128	1094

14" @ 320 LBS. WF CORE

COL. CORE	COVER PLATES		TOTAL WEIGHT	TOTAL AREA	Axis 1-1		Axis 2-2		Dimensions						BENDING FACTORS		Effective Length, Feet											
	W	T			I_1	r_1	I_2	r_2	t	d	b	c	f	o	K_c	K_e	10	12	14	16	18	20	22	24	26	28	30	32
14" @ 320# WF	18	1	442	130.1	6999	7.33	2607	4.48	1 7/8	18 13/16	18	12 5/8	11 3/8	3 1/16	1.65	.175	2166	2147	2123	2096	2065	2030	1993	1951	1906	1857	1804	1748
	18	1 1/8	458	134.6	7403	7.42	2729	4.50	1 7/8	19 1/16	18	12 5/8	11 3/8	3 3/16	1.65	.173	2242	2221	2197	2169	2138	2103	2063	2021	1975	1924	1870	1813
	18	1 1/4	473	139.1	7817	7.50	2850	4.53	1 7/8	19 5/16	18	12 5/8	11 3/8	3 5/16	1.66	.172	2317	2297	2272	2243	2211	2175	2135	2092	2045	1994	1939	1880
	20	1 1/4	490	144.1	8225	7.55	3302	4.79	1 7/8	19 3/16	20	12 5/8	11 3/8	3 5/16	1.64	.169	2406	2386	2364	2337	2308	2274	2238	2197	2154	2106	2054	2000
	20	1 3/8	507	149.1	8697	7.64	3468	4.82	1 7/8	19 9/16	20	12 5/8	11 3/8	3 7/16	1.64	.168	2490	2470	2447	2420	2390	2355	2317	2276	2232	2183	2131	2075
	20	1 1/2	524	154.1	9182	7.72	3635	4.86	1 7/8	19 13/16	20	12 5/8	11 3/8	3 9/16	1.65	.166	2574	2554	2530	2503	2472	2437	2399	2357	2312	2263	2209	2153
	22	1 1/2	544	160.1	9686	7.78	4297	5.18	1 7/8	19 13/16	22	12 5/8	11 3/8	3 9/16	1.62	.164	2680	2662	2640	2615	2587	2565	2520	2482	2440	2395	2347	2295
	22	1 5/8	563	165.6	10232	7.86	4519	5.22	1 7/8	20 1/16	22	12 5/8	11 3/8	3 11/16	1.63	.162	2773	2754	2732	2706	2678	2645	2610	2570	2528	2482	2433	2380
	22	1 3/4	582	171.1	10792	7.94	4741	5.26	1 7/8	20 5/16	22	12 5/8	11 3/8	3 13/16	1.64	.161	2865	2846	2824	2798	2769	2736	2699	2660	2617	2570	2520	2466
	22	1 7/8	601	176.6	11367	8.02	4963	5.30	1 7/8	20 9/16	22	12 5/8	11 3/8	3 15/16	1.64	.160	2958	2939	2916	2890	2860	2827	2790	2750	2705	2658	2607	2552
	22	2	619	182.1	11955	8.10	5184	5.34	1 7/8	20 13/16	22	12 5/8	11 3/8	4 1/16	1.65	.159	3051	3031	3008	2981	2951	2918	2880	2839	2794	2746	2694	2639
	22	2 1/8	638	187.6	12558	8.18	5406	5.37	1 7/8	21 1/16	22	12 5/8	11 3/8	4 3/16	1.66	.157	3144	3124	3100	3073	3042	3007	2969	2928	2882	2833	2781	2724
	22	2 1/4	657	193.1	13175	8.26	5628	5.40	1 7/8	21 5/16	22	12 5/8	11 3/8	4 5/16	1.67	.156	3237	3216	3192	3164	3133	3098	3059	3016	2970	2920	2866	2809
	22	2 3/8	675	198.6	13806	8.34	5850	5.43	1 7/8	21 9/16	22	12 5/8	11 3/8	4 7/16	1.67	.155	3329	3308	3284	3256	3224	3188	3149	3106	3058	3007	2953	2895
	22	2 1/2	694	204.1	14453	8.41	6072	5.45	1 7/8	21 13/16	22	12 5/8	11 3/8	4 9/16	1.68	.154	3422	3401	3376	3347	3314	3278	3238	3194	3146	3093	3037	2978
	22	2 5/8	713	209.6	15115	8.49	6294	5.48	1 7/8	22 1/16	22	12 5/8	11 3/8	4 11/16	1.69	.153	3514	3493	3468	3439	3405	3368	3327	3282	3234	3181	3124	3064
	22	2 3/4	731	215.1	15791	8.57	6515	5.50	1 7/8	22 5/16	22	12 5/8	11 3/8	4 13/16	1.69	.152	3607	3585	3580	3530	3496	3458	3416	3370	3321	3267	3209	3148
	23	2 3/4	750	220.6	16321	8.60	7212	5.72	1 7/8	22 5/16	23	12 5/8	11 3/8	4 13/16	1.68	.151	3703	3682	3658	3630	3597	3561	3522	3478	3432	3382	3327	3268
	23	2 7/8	770	226.4	17044	8.68	7465	5.74	1 7/8	22 9/16	23	12 5/8	11 3/8	4 15/16	1.69	.150	3801	3780	3755	3726	3693	3657	3617	3572	3524	3473	3417	3357
	23	3	789	232.1	17784	8.75	7719	5.77	1 7/8	22 13/16	23	12 5/8	11 3/8	5 1/16	1.70	.149	3897	3875	3850	3821	3788	3751	3710	3665	3616	3564	3507	3446
	24	3	810	238.1	18377	8.79	8547	5.99	1 7/8	22 13/16	24	12 5/8	11 3/8	5 1/16	1.69	.148	4002	3981	3957	3929	3897	3862	3823	3781	3734	3684	3631	3573
	24	3 1/8	830	244.1	19166	8.86	8835	6.02	1 7/8	23 1/16	24	12 5/8	11 3/8	5 3/16	1.69	.147	4103	4082	4058	4029	3997	3961	3921	3879	3832	3781	3726	3668
	24	3 1/4	850	250.1	19973	8.94	9123	6.04	1 7/8	23 5/16	24	12 5/8	11 3/8	5 5/16	1.70	.146	4204	4183	4158	4129	4096	4060	4020	3976	3928	3877	3821	3761
	24	3 3/8	871	256.1	20797	9.01	9411	6.06	1 7/8	23 9/16	24	12 5/8	11 3/8	5 7/16	1.71	.145	4305	4283	4258	4229	4196	4159	4118	4074	4024	3972	3916	3854
	24	3 1/2	891	262.1	21638	9.09	9699	6.08	1 7/8	23 13/16	24	12 5/8	11 3/8	5 9/16	1.72	.144	4406	4384	4359	4329	4295	4257	4216	4170	4121	4067	4010	3948
	24	3 5/8	912	268.1	22497	9.16	9987	6.10	1 7/8	24 1/16	24	12 5/8	11 3/8	5 11/16	1.73	.143	4507	4485	4459	4429	4395	4357	4314	4268	4218	4163	4105	4043

Example—Case 1:

Assume 14″ @ 150# Column
Length 24′-0″

Direct load, 500,000 lbs.

Eccentric Load, 40,000 lbs.

Eccentricity, $e = 12''$
(from c.*l.* column)

$A = 44.08 \qquad c = 7.44$

$r_1 = 6.37 \qquad l/r = 72$

$r_2 = 3.99 \qquad F = 14.49$

$$A = \frac{500 + 40}{14.49} + \frac{40 \times 12 \times 7.44}{20.0 \times 6.37^2} = 41.7 \ \square''$$

For equivalent concentric load:

$$P_c = P_e \frac{ce}{r^2} = 40 \frac{12 \times 7.44}{6.37^2} = 88 \text{ kips}$$

$$\text{and } A = \frac{P + P_e + P_c}{F} = \frac{500 + 40 + 88}{14.49} = 43.3 \ \square''$$

It will be noted that the equivalent load method is conservative.

Example—Case 2:

Assume 14″ @ 150# Column
Length 24′-0″

Direct load, 500,000 lbs.
at top

Eccentric load, 40,000 lbs.,
8′-0″ from top

Eccentricity, $e = 12''$
(from c.*l.* column)

$A = 44.08 \qquad c = 7.44$

$r_1 = 6.37 \qquad l/r$ as shown

$r_2 = 3.99$

$$A = \frac{P}{F} + \frac{P_e}{F_e} + \frac{P_e cek}{lF_b r^2}$$

For $l/r = 72$, $F = 14.49$

For $k/r = \dfrac{16 \times 12}{3.99} = 48$, $F_e = 15.88$ and

$$A = \frac{500}{14.49} + \frac{40}{15.88} + \frac{40 \times 7.44 \times 12 \times 16}{24 \times 20.0 \times 6.37^2} = 39.95 \ \square''$$

Note: When eccentric load is at column mid-height,

$$l_1 = l_2 = \tfrac{1}{2}l, \text{ and } A = \frac{P}{F} + \frac{P_e}{F_e} + \frac{P_e ce}{2F_b r^2}$$

Nomenclature.

A = Area of section
c = Distance, extreme fiber to axis
e = Eccentricity of P_e from axis
e_1 = Eccentricity of P_e from face of column
F = Unit compressive fiber stress, for length "*l*"
F_e = Unit compressive fiber stress, for length "k"
F_b = Unit fiber stress in bending
k = Greater distance, ecc. load from either end of col.
K_c = Constant
K_e = Constant

l = Effective column length
l_1 = Distance, top of Col. to load
l_2 = Distance, bottom Col. to load
M = Bending Moment
r = Radius of Gyration
P = Concentric load
P_e = Eccentric load
P_c = Equivalent concentric load

Note: See A. I. S. C. Specifications for basic column nomenclature.

Allowable stress $= 9{,}000 - 40\frac{l}{r}$

Maximum $\frac{l}{r} = 90.$

r = Least radius of gyration.
l = Effective length, inches.

CAST IRON COLUMNS

ALLOWABLE LOADS, IN KIPS

CARNEGIE STEEL COMPANY

ROUND

OUTER DIAM. IN.	THICK-NESS IN.	AREA SQ. IN.	WT. PER FT. LBS.	r	Length in Feet									
					8	10	12	14	16	18	20	22	24	26
5	½	7.07	22	1.60	47	42	38							
	⅝	8.59	27	1.56	56	51								
	¾	10.01	31	1.53	65	59								
	⅞	11.34	35	1.49	73	66								
5½	½	7.85	25	1.78	54	49	45							
	⅝	9.57	30	1.74	65	60	54							
	¾	11.20	35	1.70	75	69	63							
	⅞	12.71	40	1.66	85	78	70							
6	½	8.64	27	1.95	61	56	52	48						
	⅝	10.55	33	1.91	74	68	63	58						
	¾	12.37	39	1.88	86	80	73	67						
	⅞	14.09	44	1.84	97	90	82							
6½	⅝	11.54	36	2.09	83	77	72	67						
	¾	13.55	42	2.05	97	90	84	77						
	⅞	15.46	48	2.01	109	102	95	88						
	1	17.28	54	1.98	122	114	105	97						
7	⅝	12.52	39	2.27	92	86	81	76	70					
	¾	14.73	46	2.23	107	101	95	88	82					
	⅞	16.84	53	2.19	122	115	107	100	92					
	1	18.85	59	2.15	136	128	119	111	102					
7½	⅝	13.50	42	2.43	101	95	89	84	79	73				
	¾	15.90	50	2.40	118	111	105	99	92	86				
	⅞	18.21	57	2.36	135	127	120	112	105					
	1	20.42	64	2.32	150	141	133	125	116					
8	¾	17.08	53	2.58	128	122	116	109	103	96				
	⅞	19.59	61	2.54	147	139	132	124	117	110				
	1	21.99	69	2.50	164	156	147	139	130	122				
	1⅛	24.30	76	2.46	181	171	162	152	143	133				
9	⅞	22.34	70	2.89	171	164	157	149	142	134	127			
	1	25.13	79	2.85	192	184	175	167	158	150	141			
	1⅛	27.83	87	2.81	212	203	193	184	174	165	155			
	1¼	30.43	95	2.78	232	221	211	200	190	179	168			
10	1	28.28	88	3.20	221	212	204	195	187	178	170	161		
	1⅛	31.37	98	3.16	244	235	225	216	206	197	187	177		
	1¼	34.36	107	3.13	267	257	246	235	225	214	203	193		
	1⅜	37.26	116	3.09	289	277	266	254	243	231	219	208		
11	1⅛	34.90	109	3.51	276	266	257	247	238	228	219	210	200	190
	1¼	38.29	120	3.48	302	292	281	271	260	250	239	228	218	207
	1⅜	41.58	130	3.44	328	316	305	293	281	270	258	246	235	
	1½	44.77	140	3.40	352	340	327	314	302	289	277	264	251	
12	1¼	42.22	132	3.83	338	327	316	306	295	285	274	264	253	242
	1⅜	45.90	143	3.79	367	355	343	332	320	308	297	285	274	262
	1½	49.48	155	3.75	395	382	369	357	344	331	319	306	293	281
	1⅝	52.97	166	3.71	422	408	394	381	367	353	340	326	311	298
13	1⅜	50.22	157	4.14	405	394	382	370	359	347	336	324	312	300
	1½	54.19	169	4.10	437	424	412	399	386	374	361	348	335	323
	1⅝	58.07	182	4.06	468	454	440	427	413	399	385	372	358	344
	1¾	61.85	193	4.03	498	483	468	454	439	424	409	395	380	365
14	1½	58.91	184	4.45	479	467	454	441	429	416	403	390	378	365
	1⅝	63.18	197	4.41	514	500	486	472	459	445	431	417	404	389
	1¾	67.35	211	4.38	547	532	518	503	488	473	459	444	429	415
	1⅞	71.42	223	4.34	580	564	548	532	516	501	485	469	453	436
15	1⅝	68.29	213	4.76	560	546	532	518	504	491	477	463	449	436
	1¾	72.85	228	4.73	597	582	567	552	537	523	508	493	478	463
	1⅞	77.31	242	4.69	632	617	601	585	569	553	538	522	506	490
	2	81.68	255	4.65	668	651	634	617	600	583	566	550	533	516
16	1¾	78.34	245	5.08	646	631	616	601	587	572	557	542	527	513
	1⅞	83.20	260	5.04	685	670	654	638	622	606	590	574	559	543
	2	87.97	275	5.00	724	707	690	673	657	640	623	606	589	572
	2⅛	92.63	290	4.96	762	744	726	708	690	672	654	636	619	601

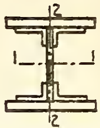
SQUARE

OUTER WIDTH IN.	THICK-NESS IN.	AREA SQ. IN.	WT. PER FT. LBS.	r	Length in Feet									
					8	10	12	14	16	18	20	22	24	26
5	½	9.00	28	1.85	62	58	53							
	⅝	10.94	34	1.80	79	69	64							
	¾	12.75	40	1.76	87	80	73							
	⅞	14.44	45	1.72	98	90	82							
5½	½	10.00	31	2.05	71	67	62	57						
	⅝	12.19	38	2.01	86	80	75	69						
	¾	14.25	45	1.96	100	93	86	80						
	⅞	16.19	51	1.92	114	105	97	89						
6	½	11.00	34	2.26	80	76	71	66	62					
	⅝	13.44	42	2.21	98	92	86	80	74					
	¾	15.75	49	2.17	114	107	100	93	86					
	⅞	17.94	56	2.12	129	121	113	104						
6½	⅝	14.69	46	2.42	109	103	97	91	85	80				
	¾	17.25	54	2.37	127	120	113	106	99					
	⅞	19.69	62	2.33	145	137	128	120	112					
	1	22.00	69	2.28	161	152	143	133	124					
7	⅝	15.94	50	2.62	120	114	108	103	97	91				
	¾	18.75	59	2.57	141	134	127	120	113	106				
	⅞	21.44	64	2.53	160	152	144	136	128	120				
	1	24.00	75	2.48	179	170	160	151	142	133				
7½	⅝	17.19	54	2.82	131	125	120	114	108	102	96			
	¾	20.25	63	2.77	154	147	140	133	126	119	112			
	⅞	23.19	73	2.73	176	168	160	152	143	135	127			
	1	26.00	81	2.68	196	187	178	169	160	150	140			
8	¾	21.75	68	2.98	168	161	154	147	140	133	126	119		
	⅞	24.94	78	2.93	192	184	175	167	159	151	143	135		
	1	28.00	88	2.89	215	205	196	187	178	168	159			
	1⅛	30.94	97	2.84	237	226	216	205	195	185	174			
9	⅞	27.44	86	3.34	215	208	200	192	184	176	168	160	153	
	1	32.00	100	3.29	251	241	232	223	213	204	195	186	176	
	1⅛	35.44	111	3.25	277	267	256	246	235	225	214	204	194	
	1¼	38.75	121	3.21	302	291	279	268	256	244	232	221	209	
10	1	36.00	113	3.70	287	277	268	259	249	240	231	221	212	203
	1⅛	39.94	125	3.65	317	307	296	286	275	265	254	244	234	223
	1¼	43.75	137	3.61	347	336	324	312	301	289	277	266	254	243
	1⅜	47.44	148	3.57	376	363	350	338	325	312	299	286	273	261
11	1⅛	44.44	139	4.06	358	347	337	326	316	305	295	284	273	263
	1¼	48.75	152	4.01	392	380	369	357	345	334	322	310	298	287
	1⅜	52.94	165	3.97	425	412	400	387	374	361	348	336	323	310
	1½	57.00	178	3.93	457	443	429	416	402	388	374	360	346	332
12	1¼	53.78	168	4.42	437	426	414	402	391	379	367	356	344	333
	1⅜	58.44	183	4.37	475	462	449	436	423	410	398	385	372	358
	1½	63.00	197	4.33	511	497	483	469	455	441	427	413	399	386
	1⅝	67.44	211	4.29	547	532	516	501	486	471	456	441	426	410
13	1⅜	63.94	200	4.78	524	511	498	486	473	460	447	434	421	409
	1½	69.00	216	4.74	565	551	537	523	509	495	481	467	453	439
	1⅝	73.94	231	4.69	605	590	575	560	544	529	514	499	484	469
	1¾	78.75	246	4.65	644	627	611	595	579	562	546	530	514	497
14	1½	75.00	234	5.14	619	605	591	577	563	549	535	521	507	493
	1⅝	80.44	251	5.10	663	648	633	618	603	588	572	557	542	527
	1¾	85.75	268	5.05	707	690	674	658	641	625	609	593	576	560
	1⅞	90.94	284	5.01	749	731	714	696	679	662	644	627	609	592
15	1⅝	86.94	272	5.50	722	707	691	676	661	646	631	616	600	585
	1¾	92.75	290	5.46	769	753	737	721	704	688	672	655	639	623
	1⅞	98.44	308	5.41	816	799	782	764	746	729	711	694	676	659
	2	104.00	325	5.37	862	843	824	806	787	769	750	731	713	694
16	1¾	99.75	312	5.86	832	816	800	783	767	751	734	718	702	685
	1⅞	105.94	331	5.82	884	866	849	831	814	796	779	761	744	726
	2	112.00	350	5.77	934	915	896	878	859	840	822	803	785	766
	2⅛	117.94	369	5.73	982	963	943	923	903	883	864	844	824	804

I = Moment of Inertia.
r = Radius of Gyration.

PLATE AND ANGLE COLUMNS

PROPERTIES



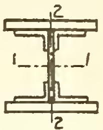
SIZE WEB PLATE	SIZE ANGLES	SIZE COVERS	TOTAL AREA SQ. IN.	TOTAL WT. LBS.	Axis 1-1		Axis 2-2	
					I	r	I	r
6x¼	2½x2 x ¼		5.74	19.6	34	2.45	6	1.04
	3 x2 x ¼		6.26	21.5	39	2.50	10	1.28
	3 x2½x ¼		6.74	23.1	43	2.51	10	1.24
	3 x2½x 5/16		7.98	27.5	52	2.53	13	1.27
	3 x2½x ⅜		9.18	31.5	60	2.54	16	1.31
8x¼	3 x2½x ¼		7.24	24.8	80	3.35	10	1.19
	3 x2½x 5/16		8.48	29.2	97	3.38	13	1.23
	3½x2½x ¼		7.76	26.4	90	3.41	16	1.44
	3½x2½x 5/16		9.12	31.2	107	3.43	20	1.49
8x5/16	3½x2½x 5/16		9.62	32.9	110	3.38	21	1.47
	3½x2½x ⅜		10.94	37.3	127	3.40	25	1.51
	4 x3 x 5/16		10.86	37.3	122	3.35	30	1.67
	4 x3 x ⅜		12.42	42.5	141	3.36	36	1.71
8x⅜	4 x3 x ⅜		12.92	44.2	143	3.33	37	1.70
	4 x3 x 7/16		14.48	49.4	161	3.34	44	1.73
	4 x3 x ½		16.00	54.6	178	3.33	50	1.77
	4 x3 x ⅝		18.92	64.6	209	3.32	63	1.82
10x¼	4 x3 x ¼		9.26	31.7	164	4.21	24	1.60
	4 x3 x 5/16		10.86	37.3	196	4.25	30	1.65
	4 x3 x ⅜		12.42	42.5	227	4.27	35	1.69
10x5/16	4 x3 x 5/16		11.48	39.4	201	4.19	30	1.63
	4 x3 x ⅜		13.04	44.6	232	4.22	36	1.67
	4 x3 x ½		16.13	55.0	290	4.25	49	1.74
10x⅜	4 x3 x ⅜		13.67	46.8	237	4.17	37	1.65
	4 x3 x 7/16		15.23	52.0	267	4.19	44	1.69
	4 x3 x ½		16.75	57.2	295	4.20	50	1.73
	5 x3½x ⅜		15.95	54.4	279	4.18	71	2.10
	5 x3½x 7/16		17.87	60.8	315	4.20	82	2.15
	5 x3½x ½		19.75	67.2	349	4.22	95	2.19
10x½	5 x3½x ½		21.00	71.4	360	4.14	98	2.16
	5 x3½x 9/16		22.88	77.8	393	4.15	111	2.20
	5 x3½x ⅝		24.68	84.2	424	4.16	123	2.23
	5 x3½x ¾		28.24	96.2	484	4.16	149	2.29
12x¼	4 x3 x ¼		9.76	33.4	247	5.03	24	1.56
	4 x3 x 5/16		11.36	39.0	295	5.09	30	1.61
	4 x3 x ⅜		12.92	44.2	341	5.13	35	1.66
12x5/16	4 x3 x 5/16		12.11	41.6	304	5.01	30	1.58
	4 x3 x ⅜		13.67	46.8	350	5.06	36	1.63
	4 x3 x 7/16		15.23	52.0	395	5.10	42	1.67
	4 x3 x ½		16.75	57.2	437	5.12	49	1.71
12x⅜	5 x3½x ⅜		16.70	56.9	421	5.02	71	2.06
	5 x3½x 7/16		18.62	63.3	476	5.05	82	2.10
	5 x3½x ½		20.50	69.7	526	5.07	95	2.15
	6 x4 x ⅜		18.94	64.5	481	5.04	119	2.51
	6 x4 x 7/16		21.22	72.5	544	5.06	139	2.56
	6 x4 x ½		23.50	80.1	605	5.07	160	2.61
12x½	6 x4 x ½		25.00	85.2	625	4.99	165	2.57
	6 x4 x 9/16		27.24	92.8	685	5.01	185	2.61
	6 x4 x ⅝		29.44	100.4	740	5.01	205	2.65
	6 x4 x 11/16		31.60	107.6	795	5.01	230	2.69
	6 x4 x ¾		33.76	114.8	850	5.01	250	2.72
12x⅝	6 x4 x ⅝		30.94	105.5	760	4.95	215	2.52
	6 x4 x 11/16		33.10	112.7	810	4.95	235	2.66
	6 x4 x ¾		35.26	119.9	865	4.96	255	2.70
	6 x4 x 13/16		37.38	127.1	920	4.96	280	2.73
	6 x4 x ⅞		39.42	134.3	970	4.97	300	2.76
12x¾	6 x4 x ¾		36.76	125.0	885	4.91	265	2.69
	6 x4 x 13/16		38.88	132.2	935	4.91	290	2.72
	6 x4 x ⅞		40.92	139.4	985	4.92	310	2.75
	6 x4 x 15/16		43.00	146.2	1035	4.91	335	2.78
	6 x4 x1		45.00	153.0	1080	4.90	355	2.82
12x⅞	6 x4 x ⅞		42.42	144.5	1005	4.87	320	2.75
	6 x4 x 15/16		44.50	151.3	1055	4.87	340	2.76
	6 x4 x1		46.50	158.1	1100	4.86	355	2.76
12x½	6 x4 x ½	14x ½	39.00	132.8	1215	5.58	395	3.18
	do.	14x ⅝	42.50	144.7	1375	5.70	450	3.26
	do.	14x ¾	46.00	156.6	1545	5.80	510	3.32
12x⅝	6 x4 x ⅝	14x ⅝	48.44	165.0	1515	5.59	499	3.21
	do.	14x ¾	51.94	176 9	1680	5.69	555	3.27
	do.	14x ⅞	55.44	188.8	1855	5.79	615	3.33
	do.	14x1	58.94	200.7	2035	5.88	670	3.37
	do.	14x1⅛	62.44	212.6	2225	5.97	730	3.41

SIZE WEB PLATE	SIZE ANGLES	SIZE COVERS	TOTAL AREA SQ. IN.	TOTAL WT. LBS.	Axis 1-1		Axis 2-2	
					I	r	I	r
12x¾	6x4x ¾	14x ¾	57.76	196.4	1805	5.60	610	3.24
	do.	14x ⅞	61.26	208.3	1980	5.69	665	3.30
	do.	14x1	64.76	220.2	2165	5.78	725	3.34
	do.	14x1⅛	68.26	232.1	2350	5.86	780	3.38
	do.	14x1¼	71.76	244.0	2545	5.95	840	3.42
12x⅞	6x4x ⅞	14x ⅞	66.92	227.9	2100	5.60	720	3.28
	do.	14x1	70.42	239.8	2285	5.70	775	3.32
	do.	14x1⅛	73.92	251.7	2470	5.78	835	3.36
	do.	14x1¼	77.42	263.6	2665	5.86	890	3.39
	do.	14x1⅜	80.92	275.5	2865	5.95	950	3.42
	do.	14x1½	84.42	287.4	3070	6.03	1005	3.45
12x1	6x4x1	14x1	84.00	258.4	2395	5.34	830	3.13
	do.	14x1⅛	87.50	270.3	2580	5.43	890	3.18
	do.	14x1¼	91.00	282.2	2775	5.52	945	3.22
	do.	14x1⅜	94.50	294.1	2975	5.62	1005	3.26
	do.	14x1½	98.00	306.0	3180	5.70	1060	3.29
14x⅜	6x4x ⅜		19.69	67.1	680	5.88	119	2.46
	6x4x 7/16		21.97	75.1	770	5.91	139	2.52
	6x4x ½		24.25	82.7	855	5.94	160	2.54
14x½	6x4x ½		26.00	88.0	885	5.83	165	2.52
	6x4x 9/16		28.24	96.2	970	5.85	186	2.56
	6x4x ⅝		30.44	103.8	1050	5.87	206	2.60
	6x4x 11/16		32.60	111.0	1125	5.89	228	2.64
	6x4x ¾		34.76	118.2	1205	5.90	249	2.67
14x⅝	6x4x ⅝		32.19	109.8	1080	5.80	215	2.57
	6x4x 11/16		34.35	117.0	1155	5.81	235	2.62
	6x4x ¾		36.51	124.2	1235	5.82	255	2.66
	6x4x 13/16		38.63	131.4	1310	5.82	280	2.68
	6x4x ⅞		40.67	138.6	1380	5.82	300	2.71
14x¾	6x4x ¾		38.26	130.1	1265	5.75	265	2.64
	6x4x ⅞		42.42	144.5	1410	5.77	310	2.70
	6x4x1		46.50	158.1	1545	5.77	355	2.76
	6x6x ¾		44.26	150.5	1295	5.41	270	2.47
	6x6x ⅞		49.42	168.1	1445	5.41	315	2.52
	6x6x1		54.50	185.3	1595	5.41	360	2.58
14x⅞	6x4x ⅞		44.17	150.5	1440	5.70	310	2.66
	6x4x1		48.25	164.1	1575	5.71	355	2.70
	6x6x ⅞		51.17	174.1	1475	5.36	325	2.52
	6x6x1		56.25	191.3	1620	5.37	375	2.58
14x1	6x4x1		50.00	170.0	1605	5.67	375	2.74
	6x6x1		58.00	197.2	1650	5.34	385	2.58
14x½	6x4x ½	14x ½	40.00	136.2	1670	6.47	395	3.14
	do.	14x ⅝	43.50	148.1	1885	6.58	450	3.22
	do.	14x ¾	47.00	160.0	2105	6.70	510	3.28
	do.	14x ⅞	50.50	171.9	2335	6.80	565	3.34
	do.	14x1	54.00	183.8	2570	6.90	620	3.39
14x⅝	6x4x ⅝	14x ⅝	49.69	169.3	2080	6.47	500	3.17
	do.	14x ¾	53.19	181.2	2300	6.58	555	3.23
	do.	14x ⅞	56.69	193.1	2530	6.68	615	3.29
	do.	14x1	60.19	205.0	2765	6.78	670	3.34
	do.	14x1⅛	63.69	216.9	3005	6.87	730	3.38
	do.	14x1¼	67.19	228.8	3255	6.96	785	3.42
14x¾	6x4x ¾	14x ¾	59.26	201.5	2485	6.48	610	3.20
	do.	14x ⅞	62.76	213.4	2715	6.58	665	3.26
	do.	14x1	66.26	225.3	2950	6.67	725	3.30
	do.	14x1⅛	69.76	237.2	3190	6.75	780	3.34
	do.	14x1¼	73.26	249.1	3440	6.85	835	3.38
	do.	14x1⅜	76.76	261.0	3695	6.93	895	3.41
	do.	14x1½	80.26	272.9	3960	7.02	950	3.44
14x¾	6x6x ¾	14x ¾	65.26	221.9	2515	6.20	610	3.06
	do.	14x ⅞	68.76	233.9	2745	6.32	670	3.12
	do.	14x1	72.26	245.7	2980	6.42	725	3.17
	do.	14x1⅛	75.76	257.6	3220	6.51	785	3.22
	do.	14x1¼	79.26	269.5	3470	6.61	840	3.26
	do.	14x1⅜	82.76	281.4	3725	6.70	900	3.29
	do.	14x1½	86.26	293.3	3990	6.80	955	3.32
14x⅞	6x4x ⅞	14x ⅞	68.67	233.9	2890	6.50	710	3.22
	do.	14x1	72.17	245.8	3125	6.58	770	3.26
	do.	14x1⅛	75.67	257.7	3365	6.67	825	3.30
	do.	14x1¼	79.17	269.6	3615	6.75	885	3.34
	do.	14x1⅜	82.67	281.5	3870	6.84	940	3.37
	do.	14x1½	86.17	293.4	4140	6.92	995	3.40

I = Moment of Inertia.
r = Radius of Gyration.

PLATE AND ANGLE COLUMNS

PROPERTIES



SIZE WEB PLATE	SIZE ANGLES	SIZE COVERS	TOTAL AREA SQ. IN.	TOTAL WT. LBS.	Axis 1-1		Axis 2-2	
					I	r	I	r
14x⅞	6x6x ⅞	14x ⅞	75.67	257.5	2925	6.22	725	3.10
	do.	14x1	79.17	269.4	3160	6.31	785	3.15
	do.	14x1⅛	82.67	281.3	3400	6.40	840	3.19
	do.	14x1¼	86.17	293.2	3650	6.50	895	3.23
	do.	14x1⅜	89.67	305.1	3905	6.60	955	3.26
	do.	14x1½	93.17	317.0	4170	6.70	1010	3.29
14x1	6x4x1	14x1	78.00	265.2	3285	6.50	830	3.27
	do.	14x1⅛	81.50	277.1	3530	6.59	890	3.30
	do.	14x1¼	85.00	289.0	3780	6.67	945	3.33
	do.	14x1⅜	88.50	300.9	4035	6.73	1005	3.37
	do.	14x1½	92.00	312.8	4300	6.83	1060	3.40
14x1	6x6x1	16x1½	106.00	360.4	4730	6.68	1410	3.65
	do.	16x1⅝	110.00	374.0	5040	6.76	1495	3.69
	do.	16x1¾	114.00	387.6	5360	6.85	1580	3.73
	do.	16x1⅞	118.00	401.2	5690	6.94	1665	3.76
	do.	16x2	122.00	414.8	6030	7.02	1750	3.79
	do.	16x2⅛	126.00	428.4	6375	7.11	1825	3.82
	do.	16x2¼	130.00	442.0	6730	7.20	1920	3.85
	do.	16x2⅜	134.00	455.6	7095	7.28	2005	3.87
	do.	16x2½	138.00	469.2	7470	7.36	2090	3.89
14x1¼	6x6x1	16x1½	109.50	372.3	4790	6.60	1450	3.64
	do.	16x1⅝	113.50	385.9	5100	6.70	1535	3.68
	do.	16x1¾	117.50	399.5	5415	6.80	1620	3.72
	do.	16x1⅞	121.50	413.1	5795	6.90	1705	3.75
	do.	16x2	125.50	426.7	6085	6.98	1790	3.78
	do.	16x2⅛	129.50	440.3	6430	7.06	1875	3.81
	do.	16x2¼	133.50	453.9	6785	7.13	1960	3.84
	do.	16x2⅜	137.50	467.5	7155	7.20	2045	3.86
	do.	16x2½	141.50	481.1	7530	7.27	2130	3.88
	do.	16x2⅝	145.50	494.7	7915	7.36	2215	3.90
	do.	16x2¾	149.50	508.3	8310	7.45	2300	3.92
14x1½	6x6x1	16x1½	113.00	384.2	4845	6.55	1480	3.62
	do.	16x1⅝	117.00	397.8	5155	6.64	1565	3.66
	do.	16x1¾	121.00	411.4	5475	6.73	1650	3.69
	do.	16x1⅞	125.00	425.0	5805	6.82	1735	3.72
	do.	16x2	129.00	438.6	6140	6.90	1820	3.75
	do.	16x2⅛	133.00	452.2	6490	6.98	1905	3.78
	do.	16x2¼	137.00	465.8	6845	7.06	1990	3.81
	do.	16x2⅜	141.00	479.4	7210	7.14	2075	3.84
	do.	16x2½	145.00	493.0	7585	7.22	2160	3.86
	do.	16x2⅝	149.00	506.6	7970	7.30	2245	3.88
	do.	16x2¾	153.00	520.2	8365	7.38	2330	3.90
	do.	16x2⅞	157.00	533.8	8770	7.46	2415	3.92
	do.	16x3	161.00	547.4	9185	7.54	2500	3.94
16x⅜	6x4x ⅜		20.44	69.7	920	6.70	120	2.42
	6x4x 7/16		22.72	77.6	1040	6.76	140	2.48
	6x4x ½		25.00	85.2	1155	6.80	160	2.53
16x½	6x4x ½		27.00	92.0	1200	6.67	165	2.47
	6x4x 9/16		29.24	99.6	1310	6.70	185	2.52
	6x4x ⅝		31.44	107.2	1425	6.73	205	2.56
	6x4x 11/16		33.60	114.4	1525	6.75	230	2.60
	6x4x ¾		35.76	121.6	1635	6.77	250	2.64
16x⅝	6x4x ⅝		33.44	114.0	1465	6.62	215	2.52
	6x4x 11/16		35.60	121.2	1570	6.65	235	2.57
	6x4x ¾		37.76	128.4	1675	6.67	255	2.61
	6x4x 13/16		39.88	135.6	1775	6.69	280	2.65
	6x4x ⅞		41.92	142.8	1875	6.70	300	2.68
	6x6x ⅝		38.44	130.8	1520	6.30	215	2.36
	6x6x 11/16		41.12	140.0	1635	6.31	240	2.40
	6x6x ¾		43.76	148.8	1740	6.31	265	2.44
	6x6x 13/16		46.36	158.0	1845	6.32	285	2.48
	6x6x ⅞		48.92	166.4	1950	6.32	310	2.52
16x¾	6x6x ¾		45.76	155.6	1780	6.24	270	2.44
	6x6x 13/16		48.36	164.8	1890	6.25	295	2.48
	6x6x ⅞		50.92	173.2	1995	6.26	320	2.52
	6x6x 15/16		53.48	182.0	2095	6.26	345	2.55
	6x6x1		56.00	190.4	2195	6.27	370	2.58
	8x6x ¾		51.76	176.0	2160	6.45	600	3.40
	8x6x 13/16		54.88	186.8	2290	6.46	650	3.44
	8x6x ⅞		57.92	197.2	2420	6.47	700	3.48
	8x6x 15/16		61.00	207.6	2550	6.47	750	3.51
	8x6x1		64.00	217.6	2675	6.47	800	3.54

SIZE WEB PLATE	SIZE ANGLES	SIZE COVERS	TOTAL AREA SQ. IN.	TOTAL WT. LBS.	Axis 1-1		Axis 2-2	
					I	r	I	r
16x⅞	6x6x ⅞		52.92	180.0	2035	6.20	330	2.50
	6x6x 15/16		55.48	188.8	2140	6.21	355	2.54
	6x6x1		58.00	197.2	2235	6.21	385	2.57
	8x6x ⅞		59.92	204.0	2465	6.41	715	3.46
	8x6x 15/16		63.00	214.4	2595	6.42	770	3.50
	8x6x1		66.00	224.4	2720	6.42	820	3.53
16x1	6x6x1		60.00	204.0	2280	6.17	395	2.56
	8x6x1		68.00	231.2	2760	6.38	840	3.51
16x¾	6x6x ¾	16x ¾	69.76	237.2	3570	7.16	785	3.35
	do.	16x ⅞	73.76	250.8	3895	7.26	870	3.43
	do.	16x1	77.76	264.4	4235	7.38	955	3.50
	do.	16x1⅛	81.76	278.0	4580	7.48	1040	3.56
	do.	16x1¼	85.76	291.6	4935	7.58	1125	3.67
	8x6x ¾	18x ¾	78.76	267.8	4170	7.28	1330	4.10
	do.	18x ⅞	83.26	283.1	4540	7.38	1450	4.17
	do.	18x1	87.76	298.4	4915	7.48	1570	4.23
	do.	18x1⅛	92.26	313.7	5310	7.58	1695	4.28
	do.	18x1¼	96.76	329.0	5710	7.67	1815	4.33
16x⅞	6x6x ⅞	16x ⅞	80.92	275.2	4150	7.18	930	3.39
	do.	16x1	84.92	288.8	4490	7.28	1015	3.46
	do.	16x1⅛	88.92	302.4	4835	7.38	1100	3.51
	do.	16x1¼	92.92	316.0	5190	7.47	1185	3.57
	do.	16x1⅜	96.92	329.6	5560	7.57	1270	3.62
	do.	16x1½	100.92	343.2	5935	7.66	1355	3.67
	8x6x ⅞	18x ⅞	91.42	311.2	4845	7.28	1565	4.14
	do.	18x1	95.92	326.5	5220	7.38	1690	4.20
	do.	18x1⅛	100.42	341.8	5615	7.48	1810	4.25
	do.	18x1¼	104.92	357.1	6015	7.58	1930	4.29
	do.	18x1⅜	109.42	372.4	6425	7.66	2055	4.33
	do.	18x1½	113.92	387.7	6850	7.74	2175	4.37
16x1	6x6x1	18x1¼	105.00	357.0	5830	7.45	1610	3.91
	do.	18x1⅜	109.50	372.3	6240	7.55	1730	3.98
	do.	18x1½	114.00	387.6	6665	7.65	1855	4.03
	do.	18x1⅝	118.50	402.9	7095	7.74	1975	4.08
	do.	18x1¾	123.00	418.2	7540	7.82	2095	4.12
	8x6x1	18x1¼	113.00	384.2	6310	7.46	2055	4.27
	do.	18x1⅜	117.50	399.5	6725	7.56	2180	4.31
	do.	18x1½	122.00	414.8	7145	7.65	2300	4.34
	do.	18x1⅝	126.50	430.1	7580	7.74	2420	4.37
	do.	18x1¾	131.00	445.4	8020	7.82	2540	4.40
16x1¼	6x6x1	18x1½	118.00	401.2	6750	7.57	1885	4.00
	do.	18x1⅝	122.50	416.5	7180	7.66	2005	4.04
	do.	18x1¾	127.00	431.8	7625	7.75	2125	4.08
	do.	18x1⅞	131.50	447.1	8080	7.84	2245	4.13
	do.	18x2	136.00	462.4	8550	7.92	2370	4.17
	8x6x1	18x1½	126.00	428.4	7230	7.58	2345	4.32
	do.	18x1⅝	130.50	443.7	7665	7.67	2465	4.35
	do.	18x1¾	135.00	459.0	8110	7.75	2585	4.38
	do.	18x1⅞	139.50	474.3	8565	7.84	2705	4.41
	do.	18x2	144.00	489.6	9030	7.91	2830	4.43
16x1½	8x6x1	18x2	148.00	503.2	9115	7.85	2875	4.40
	do.	18x2⅛	152.50	518.5	9595	7.92	2995	4.43
	do.	18x2¼	157.00	533.8	10085	8.01	3115	4.45
	do.	18x2⅜	161.50	549.1	10585	8.10	3240	4.47
	do.	18x2½	166.00	564.4	11100	8.17	3360	4.49
16x1¾	8x6x1	18x2	152.00	516.8	9200	7.78	2925	4.39
	do.	18x2⅛	156.50	532.1	9680	7.85	3045	4.42
	do.	18x2¼	161.00	547.4	10170	7.95	3165	4.44
	do.	18x2⅜	165.50	562.7	10670	8.04	3290	4.46
	do.	18x2½	170.00	578.0	11185	8.10	3410	4.48
	do.	18x2¾	179.00	608.6	12250	8.27	3655	4.51
	do.	18x3	188.00	639.2	13365	8.43	3900	4.55
16x2	8x6x1	18x2½	174.00	591.6	11275	8.05	3455	4.45
	do.	18x2⅝	178.50	606.9	11800	8.14	3580	4.48
	do.	18x2¾	183.00	622.2	12335	8.22	3700	4.50
	do.	18x2⅞	187.50	637.5	12890	8.30	3820	4.52
	do.	18x3	192.00	652.8	13450	8.37	3945	4.54
	do.	18x3⅛	196.50	668.1	14025	8.46	4065	4.56
	do.	18x3¼	201.00	683.4	14615	8.53	4185	4.58
	do.	18x3⅜	205.50	698.7	15215	8.60	4305	4.59
	do.	18x3½	210.00	714.0	15830	8.67	4425	4.60
	do.	18x4	228.00	775.2	18425	9.00	4915	4.65

Fiber stress = 19,000 — $100 \frac{l}{r}$;
Max. 13,000

Loads above upper heavy line for ratios l/r less than 60; between heavy lines up to 120; below last heavy line, up to 200.

STEEL PIPE COLUMNS

ALLOWABLE LOAD IN KIPS

Carnegie Steel Co.

STANDARD PIPE

Nominal Size, In.		15	14	13	12	11	10	9	8	7	6	5	4½	4	3½	3	2½	2	1½
External Dia., In.		16.000	15.000	14.000	12.750	11.750	10.750	9.625	8.625	7.625	6.625	5.563	5.000	4.500	4.000	3.500	2.875	2.375	1.900
Thickness In.		.375	.375	.375	.375	.375	.365	.342	.322	.301	.280	2.58	2.47	.237	.226	216	.203	.154	.145
EFFECTIVE LENGTH, IN FEET	5	239.3	224.0	208.7	189.5	174.2	154.8	129.6	109.2	90.1	72.5	55.9	48.0	41.2	34.8	29.0	21.6	12.2	7.5
	6	239.3	224.0	208.7	189.5	174.2	154.8	129.6	109.2	90.1	72.5	55.9	48.0	41.2	34.8	28.6	19.4	10.6	6.0
	7	239.3	224.0	208.7	189.5	174.2	154.8	129.6	109.2	90.1	72.5	55.9	48.0	41.2	34.1	26.3	17.3	9.0	5.0
	8	239.3	224.0	208.7	189.5	174.2	154.8	129.6	109.2	90.1	72.5	55.9	48.0	40.1	31.7	24.0	15.1	7.4	4.2
	9	239.3	224.0	208.7	189.5	174.2	154.8	129.6	109.2	90.1	72.5	55.9	46.4	37.6	29.3	21.7	12.9	6.6	3.5
	10	239.3	224.0	208.7	189.5	174.2	154.8	129.6	109.2	90.1	72.5	54.2	43.8	35.1	26.9	19.4	11.4	5.8	2.7
	11	239.3	224.0	208.7	189.5	174.2	154.8	129.6	109.2	90.1	72.5	51.5	41.2	32.6	24.5	17.1	10.3	5.0	
	12	239.3	224.0	208.7	189.5	174.2	154.8	129.6	109.2	90.1	70.2	48.7	38.5	30.0	22.1	15.2	9.2	4.1	
	13	239.3	224.0	208.7	189.5	174.2	154.8	129.6	109.2	89.9	67.3	46.0	35.9	27.5	19.7	14.0	8.1	3.3	
	14	239.3	224.0	208.7	189.5	174.2	154.8	129.6	109.2	86.7	64.3	43.2	33.3	25.0	18.0	12.9	7.0		
	15	239.3	224.0	208.7	189.5	174.2	154.8	129.6	108.1	83.5	61.3	40.5	30.6	22.5	16.8	11.7	6.0		
	16	239.3	224.0	208.7	189.5	174.2	154.8	129.6	104.7	80.3	58.3	37.7	28.0	21.1	15.6	10.6			
	17	239.3	224.0	208.7	189.5	174.2	154.8	127.5	101.3	77.1	55.3	35.0	25.6	19.8	14.4	9.4			
	18	239.3	224.0	208.7	189.5	174.2	154.8	123.9	97.8	73.9	52.3	32.2	24.3	18.6	13.2	8.3			
	19	239.3	224.0	208.7	189.5	174.2	152.4	120.3	94.4	70.7	49.4	29.8	23.0	17.3	12.0	7.1			
	20	239.3	224.0	208.7	189.5	174.2	148.5	116.6	91.0	67.5	46.4	28.4	21.7	16.0	10.8				
	21	239.3	224.0	208.7	189.5	170.7	144.6	113.0	87.6	64.3	43.4	27.0	20.3	14.8	9.6				
	22	239.3	224.0	208.7	189.1	166.7	140.7	109.3	84.1	61.1	40.4	25.7	19.0	13.5	8.4				
	23	239.3	224.0	208.7	185.1	162.7	136.8	105.7	80.7	57.8	38.3	24.3	17.7	12.3					
	24	239.3	224.0	208.7	181.1	158.7	132.9	102.0	77.3	54.6	36.8	22.9	16.4	11.0					
	25	239.3	224.0	205.0	177.1	154.7	129.0	98.4	73.8	51.4	35.3	21.6	15.1	9.7					
	26	239.3	223.4	201.0	173.1	150.7	125.1	94.7	70.4	48.4	33.8	20.2	13.8						
	27	239.3	219.4	197.0	169.1	146.7	121.3	91.1	67.0	46.7	32.3	18.8	12.4						
	28	237.9	215.4	193.0	165.1	142.7	117.4	87.5	63.5	45.1	30.8	17.4	11.1						
	29	233.9	211.4	189.0	161.1	138.7	113.5	83.8	60.1	43.5	29.3	16.1							
	30	229.9	207.4	185.0	157.1	134.7	109.6	80.2	57.7	41.9	27.8	14.7							
Area, □"		18.41	17.23	16.05	14.58	13.40	11.91	9.97	8.40	6.93	5.58	4.30	3.69	3.17	2.68	2.23	1.70	1.08	0.80
I, In.^{4}		562.1	461.0	372.8	279.3	217.0	160.7	107.6	72.5	46.5	28.1	15.2	10.4	7.23	4.79	3.02	1.53	0.666	0.310
r, In.		5.526	5.172	4.819	4.377	4.024	3.674	3.284	2.938	2.592	2.245	1.878	1.683	1.510	1.337	1.164	0.947	0.787	0.623
Weight Lbs. Per Ft.		62.58	58.57	54.57	49.56	45.56	40.48	33.91	28.55	23.54	18.97	14.62	12.54	10.79	9.11	7.58	5.79	3.65	2.72

EXTRA STRONG PIPE

Nominal Size, In.		15	14	13	12	11	10	9	8	7	6	5	4½	4	3½	3	2½	2	1½
External Dia., In.		16.000	15.000	14.000	12.750	11.750	10.750	9.625	8.625	7.625	6.625	5.563	5.000	4.500	4.000	3.500	2.875	2.375	1.900
Thickness In.		.500	.500	.500	.500	.500	.500	.500	.500	.500	.432	.375	.355	.337	.318	.300	.276	.218	.200
EFFECTIVE LENGTH, IN FEET	5	316.6	296.1	275.7	250.1	229.7	209.3	186.3	165.9	145.5	109.3	79.4	67.3	57.3	47.8	39.3	28.2	16.5	9.7
	6	316.6	296.1	275.7	250.1	229.7	209.3	186.3	165.9	145.5	109.3	79.4	67.3	57.3	47.8	38.2	25.3	14.2	7.6
	7	316.6	296.1	275.7	250.1	229.7	209.3	186.3	165.9	145.5	109.3	79.4	67.3	57.3	46.3	35.0	22.3	11.9	6.5
	8	316.6	296.1	275.7	250.1	229.7	209.3	186.3	165.9	145.5	109.3	79.4	67.3	55.1	42.9	31.8	19.4	10.0	5.4
	9	316.6	296.1	275.7	250.1	229.7	209.3	186.3	165.9	145.5	109.3	79.4	64.5	51.5	39.5	28.6	16.5	8.8	4.4
	10	316.6	296.1	275.7	250.1	229.7	209.3	186.3	165.9	145.5	109.3	76.3	60.7	47.9	36.1	25.4	14.7	7.6	3.3
	11	316.6	296.1	275.7	250.1	229.7	209.3	186.3	165.9	145.5	109.1	72.3	56.9	44.4	32.7	22.3	13.2	6.5	
	12	316.6	296.1	275.7	250.1	229.7	209.3	186.3	165.9	145.5	104.6	68.3	53.1	40.8	29.4	20.1	11.7	5.3	
	13	316.6	296.1	275.7	250.1	229.7	209.3	186.3	165.9	143.5	100.0	64.3	49.4	37.2	26.0	18.5	10.3	4.2	
	14	316.6	296.1	275.7	250.1	229.7	209.3	186.3	165.9	138.2	95.4	60.3	45.6	33.6	24.2	16.9	8.8		
	15	316.6	296.1	275.7	250.1	229.7	209.3	186.3	162.6	132.9	90.8	56.3	41.8	30.4	22.5	15.3	7.3		
	16	316.6	296.1	275.7	250.1	229.7	209.3	186.3	157.3	127.5	86.2	52.3	38.0	28.6	20.8	13.7			
	17	316.6	296.1	275.7	250.1	229.7	209.3	181.8	152.0	122.2	81.6	48.3	35.3	26.9	19.1	12.1			
	18	316.6	296.1	275.7	250.1	229.7	209.3	176.5	146.7	116.9	77.0	44.3	33.4	25.1	17.4	10.5			
	19	316.6	296.1	275.7	250.1	229.7	204.7	171.2	141.4	111.6	72.4	41.6	31.5	23.3	15.7	8.9			
	20	316.6	296.1	275.7	250.1	229.2	199.4	165.8	136.0	106.3	67.8	39.6	29.6	21.5	14.0				
	21	316.6	296.1	275.7	250.1	223.9	194.1	160.5	130.7	100.9	63.2	37.6	27.7	19.7	12.4				
	22	316.6	296.1	275.7	248.4	218.5	188.8	155.2	125.4	95.6	58.6	35.6	25.8	17.9					
	23	316.6	296.1	275.7	243.1	213.2	183.4	149.9	120.1	90.3	56.4	33.6	23.9	16.1					
	24	316.6	296.1	275.1	237.7	207.9	178.1	144.5	114.8	85.0	54.1	31.6	22.1	14.3					
	25	316.6	296.1	269.8	232.4	202.6	172.8	139.2	109.4	79.7	51.8	29.6	20.2						
	26	316.6	294.3	264.4	227.1	197.2	167.5	133.9	104.1	76.4	49.5	27.6	18.3						
	27	316.6	288.9	259.1	221.8	191.9	162.2	128.6	98.8	73.7	47.2	25.6	16.4						
	28	313.4	283.6	253.8	216.4	186.6	156.8	123.3	93.5	71.0	44.9	23.6							
	29	308.1	278.3	248.4	211.1	181.3	151.5	117.9	88.7	68.4	42.6	21.6							
	30	302.8	273.0	243.1	205.8	175.9	146.2	112.6	86.1	65.7	40.3	19.6							
Area, □"		24.35	22.78	21.21	19.24	17.67	16.10	14.33	12.76	11.19	8.40	6.11	5.18	4.41	3.68	3.02	2.25	1.48	1.07
I, In.^{4}		731.9	599.3	483.8	361.5	280.1	212.0	149.6	105.7	71.4	40.5	20.7	14.0	9.61	6.28	3.89	1.92	0.868	0.391
r, In.		5.483	5.130	4.776	4.335	3.981	3.628	3.231	2.878	2.525	2.195	1.839	1.647	1.477	1.307	1.136	0.924	0.767	0.605
Weight Lbs. Per Ft.		82.77	77.43	72.09	65.42	60.08	54.74	48.73	43.39	38.05	28.57	20.78	17.61	14.98	12.51	10.25	7.66	5.02	3.63

WEIGHTS OF COLUMN BASE SLABS
IN POUNDS

Note—Use Plates for Sizes ¾″ to 1¼″ Inc.

WIDTH IN.	LENGTH IN.	Thickness Slab, In Inches								
		¾	1	1¼	1½	2	2½	3	3½	4
8″	6	10	14							
	7	12	16							
	8	14	18							
	9	15	20							
	10	17	23							
	12	20	27							
10″	9	19	25							
	10	21	28							
	11	23	31							
	12	25	34							
	13	28	37							
	14	30	40							
12″	9	23	30	38						
	10	25	34	42						
	11	28	37	47						
	12	30	41	51						
	13	33	44	55						
	14	35	48	60						
14″	10	30	40	49						
	11	33	44	54						
	12	36	48	60						
	13	39	51	65						
	14	41	55	69						
	15	44	59	74						
	16	47	63	79						
16″	14	47	63	79	95	127				
	15	51	68	85	102	136				
	16	54	72	91	109	145				
	17	58	77	96	115	154				
	18	61	81	102	122	163				
	19	64	86	107	129	172				
	20	68	91	113	136	181				
20″	16	68	91	113	136	181	226			
	17	72	96	120	144	193	241			
	18	76	102	127	153	204	255			
	19	81	108	134	161	215	269			
	20	85	113	141	170	226	283			
	21	89	119	148	178	238	297			
	22	94	125	155	187	249	311			
	23	98	130	163	195	261	326			
	24	102	136	170	204	272	340			
24″	21						356	427		
	22						375	449		
	23						390	468		
	24						407	490		
	25						425	510		
	26						441	530		
	27						458	550		
	28						475	570		
28″	25							595	695	
	26							620	722	
	27							644	751	
	28							666	778	
	29							690	805	
	30							714	836	
	31							738	862	
	32							763	880	
32″	29								920	1052
	30								952	1088
	31								985	1124
	32								1014	1160
	33								1046	1198
	34								1078	1232
	35								1110	1268
	36								1146	1304

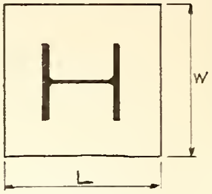
WIDTH IN.	LENGTH IN.	Thickness Slab, In Inches								
		4	4½	5	5½	6	6½	7	8	9
36″	33	1345	1510							
	34	1388	1560							
	35	1430	1605							
	36	1465	1650							
	37	1510	1700							
	38	1550	1740							
	39	1590	1790							
	40	1630	1830							
40″	37		1885	2090						
	38		1940	2155						
	39		1990	2210						
	40		2040	2260						
	41		2090	2320						
	42		2140	2370						
	43		2190	2430						
	44		2240	2490						
44″	41			2550	2810	3065				
	42			2620	2880	3140				
	43			2680	2950	3220				
	44			2740	3020	3290				
	45			2800	3080	3360				
	46			2870	3160	3440				
	47			2920	3220	3510				
	48			2980	3280	3580				
48″	45				3360	3660	3970			
	46				3440	3750	4060			
	47				3530	3850	4160			
	48				3590	3920	4240			
	49				3660	3990	4320			
	50				3740	4080	4420			
	51				3810	4160	4500			
	52				3880	4240	4590			
52″	49					4290	4650			
	50					4420	4790			
	51					4500	4870			
	52					4590	4970			
	53					4680	5070			
	54					4760	5160			
	55					4850	5260			
	56					4940	5350			
56″	53						5450	5870		
	54						5550	5980		
	55						5670	6110		
	56						5780	6230		
	57						5860	6320		
	58						5950	6410		
	59						6080	6550		
	60						6190	6650		
60″	57							6780	7750	
	58							6890	7880	
	59							7020	8030	
	60							7150	8160	
	61							7250	8300	
	62							7380	8430	
	63							7500	8580	
	64							7620	8700	
66″	61								9130	10250
	62								9270	10400
	63								9450	10620
	64								9560	10740
	65								9730	10930
	66								9850	11080
	67								10000	11250
	68								10150	11420
	69								10320	11610

Allowable Bending
Stress = 20000#/□″

COLUMN BASE SLABS

ROLLED STEEL

FOR ROLLED STEEL H-COLUMNS



Plates 4″ thick, or under, may be flattened by pressing. For plates greater than 4″ in thickness, include allowance for planing; both sides if on grillage; one side otherwise.

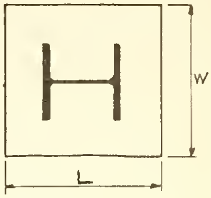
NOMINAL SIZE	COLUMN			MAX. COL. LOAD	UNIT PRESSURE 600 LBS. SQ. IN.					UNIT PRESSURE 800 LBS. SQ. IN.				
	WEIGHT PER FOOT	DEPTH	FLANGE WIDTH		THICKNESS		DIMENSION		GROSS WEIGHT	THICKNESS		DIMENSION		GROSS WEIGHT
					FIN.	ROLLED	W	L		FIN.	ROLLED	W	L	
14x16	426	18.69	16.695	2113	7	7½	59	60	7522	6⅝	7	51	52	5259
	398	18.31	16.590	1973	6⅝	7	56	59	6552	6⅛	6½	48	52	4596
	370	17.94	16.475	1834	6⅝	7	55	56	6108	6⅛	6½	48	48	4243
	342	17.56	16.365	1696	6⅛	6½	52	55	5267	5¾	6	44	48	3590
	314	17.19	16.235	1556	5¾	6	50	52	4419	5¾	6	44	44	3291
	287	16.81	16.130	1422	5¼	5½	48	50	3740	5¼	5½	41	44	2811
	264	16.50	16.025	1308	5¼	5½	46	48	3440	4¾	5	40	41	2323
	246	16.25	15.945	1219	4¾	5	44	46	2867	4¾	5	38	40	2153
	237	16.12	15.910	1174	4¾	5	44	45	2805	4¼	4½	37	40	1887
	228	16.00	15.865	1130	4¾	5	43	44	2680	4¼	4½	36	39	1790
	219	15.87	15.825	1084	4¾	5	41	44	2555	4¼	4½	36	38	1550
	211	15.75	15.800	1046	4¾	5	40	44	2493	4	4	36	37	1509
	202	15.63	15.750	1001	4¼	4½	40	42	2142	4	4	35	36	1428
	193	15.50	15.710	956	4¼	4½	40	40	2040	4	4	33	36	1346
	184	15.38	15.660	911	4¼	4½	38	40	1938	4	4	32	36	1305
	176	15.25	15.640	871	4	4	36	41	1673	3½	3½	32	34	1079
	167	15.12	15.600	827	4	4	36	39	1591	3½	3½	32	33	1047
	158	15.00	15.550	783	4	4	36	37	1509	3½	3½	31	32	984
	150	14.88	15.515	742	4	4	35	36	1428	3½	3½	29	32	920
	142	14.75	15.500	705	4	4	33	36	1346	3½	3½	28	32	888
14x14½	136	14.75	14.740	673	3½	3½	32	35	1111	3	3	28	30	714
	127	14.62	14.690	628	3½	3½	32	33	1047	3	3	28	28	666
	119	14.50	14.650	589	3½	3½	31	32	984	3	3	27	28	643
	111	14.37	14.620	549	3	3	28	33	785	3	3	25	28	595
	103	14.25	14.575	509	3	3	28	31	738	2½	2½	24	27	459
	95	14.12	14.545	470	3	3	28	28	666	2½	2½	24	25	425
	87	14.00	14.500	430	3	3	26	28	619	2	2	23	24	313
14x12	84	14.18	12.023	413	2½	2½	24	29	493	2½	2½	22	24	374
	78	14.06	12.000	384	2½	2½	24	27	459	2	2	20	24	272
14x10	74	14.19	10.072	361	2½	2½	24	25	425	2	2	19	24	258
	68	14.06	10.040	332	2½	2½	23	24	391	2	2	18	24	245
	61	13.91	10.000	297	2	2	21	24	286	2	2	16	24	218
14x8	53	13.94	8.062	254	2	2	18	24	245	2	2	16	20	181
	48	13.81	8.031	230	2	2	16	24	218	2	2	15	20	170
	43	13.68	8.000	206	1½	1½	16	22	150	2	2	13	20	147
12x12	190	14.38	12.670	936	4¾	5	39	40	2210	4	4	33	36	1346
	161	13.88	12.515	794	4	4	36	37	1509	4	4	31	32	1124
	133	13.38	12.365	655	3½	3½	32	34	1079	3½	3½	28	29	805
	120	13.12	12.320	591	3½	3½	31	32	984	3	3	27	28	643
	106	12.88	12.230	522	3	3	28	31	738	3	3	24	27	551
	99	12.75	12.190	487	3	3	28	29	690	2½	2½	24	26	442
	92	12.62	12.155	453	3	3	27	28	643	2½	2½	24	24	408
	85	12.50	12.105	418	3	3	25	28	595	2½	2½	22	24	374
	79	12.38	12.080	388	2½	2½	24	27	459	2½	2½	21	24	357
	72	12.25	12.040	354	2½	2½	24	25	425	2	2	20	22	249
	65	12.12	12.000	320	2	2	22	24	299	2	2	20	20	227
12x10	58	12.19	10.014	283	2	2	20	24	272	2	2	18	20	204
	53	12.06	10.000	258	2	2	18	24	245	2	2	17	20	193
12x8	50	12.19	8.077	240	2	2	17	24	231	2	2	15	20	170
	45	12.06	8.042	216	2	2	16	23	209	1½	1½	14	20	119
	40	11.94	8.000	192	1½	1½	16	20	136	1½	1½	14	18	107
10x10	112	11.38	10.415	548	3½	3½	29	32	920	3	3	25	28	595
	100	11.12	10.345	490	3	3	28	29	690	3	3	24	26	530
	89	10.88	10.275	436	3	3	26	28	619	3	3	23	24	469
	77	10.62	10.195	377	2½	2½	24	26	442	2½	2½	20	24	340
	72	10.50	10.170	352	2½	2½	25	24	425	2½	2½	20	22	312
	66	10.38	10.117	323	2½	2½	23	24	391	2½	2½	20	21	297
	60	10.25	10.075	294	2½	2½	21	24	357	2	2	19	20	215
	54	10.12	10.028	264	2	2	20	22	249	2	2	17	20	193
	49	10.00	10.000	239	2	2	20	20	227	2	2	16	19	172
10x8	45	10.12	8.022	217	2	2	18	20	204	2	2	16	17	154
	39	9.94	7.990	188	2	2	16	20	181	1½	1½	14	17	101
	33	9.75	7.964	159	1½	1½	16	17	116	1½	1½	13	16	88
8x8	67	9.00	8.287	324	2½	2½	23	24	391	2½	2½	20	21	297
	58	8.75	8.222	280	2½	2½	20	24	340	2	2	18	20	204
	48	8.50	8.117	232	2	2	20	20	227	2	2	16	18	163
	40	8.25	8.077	193	2	2	16	20	181	1½	1½	15	16	102
	35	8.12	8.027	169	2	2	16	18	163	1½	1½	14	16	95
	31	8.00	8.000	149	1½	1½	16	16	109	1½	1½	14	14	83
8x6½	28	8.06	6.540	132	1½	1½	14	16	95	1½	1½	12	14	71
	24	7.93	6.500	113	1½	1½	14	14	83	1½	1½	12	14	71

Allowable Bending
Stress = 20000 #/☐″

COLUMN BASE SLABS

FOR LIGHT BEARING PRESSURES

100 TO 400 LBS. PER SQUARE INCH

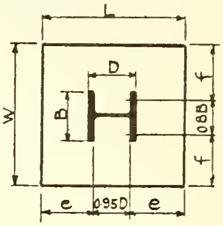


Thickness "T" is the calculated thickness required, net
This table is provided for those cases where light columns bear on brick or masonry

ALLOWABLE PRESSURE LBS. PER SQ. IN.	COLUMN LOADS, KIPS	COLUMN SECTION AND MINIMUM DIMENSIONS																													
		4″ 4 x 4			5″ 5 x 5			6″ 6 x 4			6″ 6 x 6			8″ 8 x 4			8″ 8 x 6½			8″ 8 x 8			10″ 10 x 5¾			10″ 10 x 8			10″ 10 x 10		
		L	W	T	L	W	T	L	W	T	L	W	T	L	W	T	L	W	T	L	W	T	L	W	T	L	W	T	L	W	T
100	10	10	10	.42	10	10	.37	10	10	.42	10	10	.32	10	10	.42	10	10	.31	10	10	.22									
	20	15	14	.69	15	14	.63	15	14	.66	15	14	.57	15	14	.70	15	14	.54	15	14	.47	15	14	.58	15	14	.48	15	14	.37
	30	18	17	.87	18	17	.82	18	17	.85	18	17	.76	18	17	.85	18	17	.73	18	17	.65	18	17	.76	18	17	.65	18	17	.56
	40	20	20	1.04	20	20	.98	20	20	1.03	20	20	.93	20	20	1.03	20	20	.91	20	20	.84	20	20	.95	20	20	.84	20	20	.74
	50	24	21	1.24	24	21	1.18	24	21	1.12	24	21	1.12	24	21	1.09	24	21	1.01	24	21	1.01	24	21	1.01	24	21	.90	24	21	.89
	60	25	24	1.30	25	24	1.24	25	24	1.28	25	24	1.18	25	24	1.27	25	24	1.15	25	24	1.08	25	24	1.19	25	24	1.08	25	24	.98
	70				28	25	1.42	28	25	1.37	28	25	1.37	28	25	1.34	28	25	1.25	28	25	1.25	28	25	1.25	28	25	1.14	28	25	1.14
	80				29	28	1.50	29	28	1.52	29	28	1.43	29	28	1.52	29	28	1.40	29	28	1.32	29	28	1.44	29	28	1.32	29	28	1.22
	90				30	30	1.60				32	28	1.61	32	28	1.52	32	28	1.50	32	28	1.50	32	28	1.44	32	28	1.38	32	28	1.38
	100										32	31	1.61				32	31	1.58	32	31	1.51	32	31	1.62	32	31	1.51	32	31	1.41
200	10	8	7	.37	8	7	.28	8	7	.33	8	7	.20	8	7	.33	8	7	.16												
	20	10	10	.59	10	10	.52	10	10	.59	10	10	.46	10	10	.59	10	10	.42	10	10	.32									
	30	13	12	.80	13	12	.72	13	12	.76	13	12	.64	13	12	.76	13	12	.59	13	12	.49	13	12	.66	13	12	.49	13	12	.35
	40	15	14	.97	15	14	.89	15	14	.94	15	14	.81	15	14	.94	15	14	.76	15	14	.66	15	14	.84	15	14	.66	15	14	.52
	50	16	16	1.11	16	16	1.04	16	16	1.11	16	16	.97	16	16	1.04	16	16	.94	16	16	.84	16	16	1.01	16	16	.83	16	16	.70
	60	18	17	1.23	18	17	1.15	18	17	1.20	18	17	1.07	18	17	1.15	18	17	1.01	18	17	.92	18	17	1.09	18	17	.92	18	17	.78
	70				20	18	1.32	20	18	1.29	20	18	1.24	20	18	1.32	20	18	1.11	20	18	1.07	20	18	1.18	20	18	1.01	20	18	.91
	80				20	20	1.39	20	20	1.59	20	20	1.32	20	20	1.39	20	20	1.28	20	20	1.18	20	20	1.35	20	20	1.18	20	20	1.04
	90				23	20	1.58				23	20	1.50	23	20	1.58	23	20	1.34	23	20	1.34	23	20	1.35	23	20	1.18	23	20	1.17
	100										24	21	1.59				24	21	1.42	24	21	1.42	24	21	1.44	24	21	1.27	24	21	1.26
	110										24	23	1.60				24	23	1.54	24	23	1.44	24	23	1.61	24	23	1.44	24	23	1.30
	120										25	24	1.68				25	24	1.63	25	24	1.53	25	24	1.70	25	24	1.53	25	24	1.39
	130																27	24	1.68	27	24	1.68	27	24	1.70	27	24	1.53	27	24	1.52
	140																			28	25	1.77	28	25	1.79	28	25	1.61	28	25	1.61
	150																			28	27	1.79	28	27	1.97	28	27	1.79	28	27	1.65
300	60				15	14	1.09	15	14	1.15	15	14	.99	15	14	1.15	15	14	.94	15	14	.81	15	14	1.02	15	14	.81	15	14	.64
	70				16	15	1.20	16	15	1.25	16	15	1.10	16	15	1.25	16	15	1.04	16	15	.91	16	15	1.13	16	15	.91	16	15	.76
	80				17	16	1.30	17	16	1.36	17	16	1.20	17	16	1.36	17	16	1.15	17	16	1.02	17	16	1.23	17	16	1.02	17	16	.85
	90				18	17	1.41				18	17	1.31	18	17	1.47	18	17	1.26	18	17	1.12	18	17	1.34	18	17	1.12	18	17	.96
	100										19	18	1.41				19	18	1.36	19	18	1.23	19	18	1.44	19	18	1.23	19	18	1.06
	110										20	18	1.52				20	18	1.36	20	18	1.32	20	18	1.44	20	18	1.23	20	18	1.11
	120										20	20	1.61				20	20	1.57	20	20	1.44	20	20	1.66	20	20	1.44	20	20	1.27
	130																22	20	1.57	22	20	1.52	22	20	1.66	22	20	1.52	22	20	1.33
	140																			24	20	1.74	24	20	1.66	24	20	1.54	24	20	1.54
	150																			24	21	1.74	24	21	1.76	24	21	1.55	24	21	1.55
	160																			24	22	1.74	24	22	1.87	24	22	1.66	24	22	1.55
	170																			24	24	1.87	24	24	2.08	24	24	1.87	24	24	1.70
	180																			25	24	1.87	25	24	2.08	25	24	1.87	25	24	1.70
	190																			26	24	1.95	26	24	2.08	26	24	1.87	26	24	1.75
	200																			28	24	2.14	28	24	2.08	28	24	1.96	28	24	1.96
400	60				13	12	1.01	13	12	1.08	13	12	.89	13	12	1.08	13	12	.83	13	12	.69	13	12	.93	13	12	.69	13	12	.49
	70				14	13	1.13	14	13	1.20	14	13	1.02	14	13	1.20	14	13	.96	14	13	.81	14	13	1.05	14	13	.81	14	13	.62
	80				14	14	1.22	14	14	1.33	14	14	1.14	14	14	1.33	14	14	1.08	14	14	.94	14	14	1.18	14	14	.94	14	14	.74
	90				16	14	1.38				16	14	1.27	16	14	1.33	16	14	1.08	16	14	1.03	16	14	1.18	16	14	.94	16	14	.80
	100										16	16	1.37				16	16	1.32	16	16	1.18	16	16	1.42	16	16	1.18	16	16	.98
	110										17	16	1.39				17	16	1.32	17	16	1.18	17	16	1.42	17	16	1.18	17	16	.98
	120										18	17	1.63				18	17	1.40	18	17	1.40	18	17	1.42	18	17	1.18	18	17	1.17
	130																18	18	1.57	18	18	1.42	18	18	1.67	18	18	1.42	18	18	1.23
	140																			20	18	1.52	20	18	1.67	20	18	1.42	20	18	1.29
	150																			20	19	1.55	20	19	1.79	20	19	1.55	20	19	1.35
	160																			20	20	1.67	20	20	1.91	20	20	1.67	20	20	1.47
	170																			21	20	1.67	21	20	1.91	21	20	1.67	21	20	1.47
	180																			23	20	1.89	23	20	1.91	23	20	1.67	23	20	1.67
	190																			24	20	2.01	24	20	1.91	24	20	1.78	24	20	1.78
	200																			24	21	2.01	24	21	2.04	24	21	1.79	24	21	1.79

STEEL SLAB COLUMN BASES AND GRILLAGES

The advent of the modern, multi-tiered building has radically changed the methods of transmitting the column loads to footings and foundations. The elimination, to a large extent, of the cast iron pedestals and steel beam grillages formerly used has been due to a large extent, to the introduction of the rolled steel base slab. Three methods of calculation are commonly used in the determination of the slab thickness, the difference being due to variation in assumption as to where the maximum moment occurs in the slab. Method 1 considers that the point of maximum moment is at the center line of the column; Method 2 is based on the projection of the slab beyond column face acting as a cantilever; Method 3, that adopted by the American Institute of Steel Construction, assumes that the cantilever is slightly longer than in Method 2, the column depth affecting the slab being considered as 0.95, the actual depth dimension, and the width as 0.8, the actual flange width. The moment formulae for the three methods follow. Method 3 has been used in the preparation of the tables in this book.



For a strip of slab 1 inch in width:

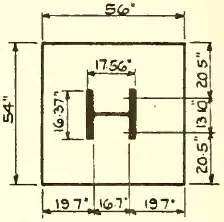
Method 1— $M = \frac{p(W^2 - B^2)}{8}$ or $\frac{p(L^2 - D^2)}{8}$ whichever governs.

Method 2— $M = \frac{p(W - B)^2}{8}$ or $\frac{p(L - D)^2}{8}$ whichever governs.

Method 3— $M = \frac{pe^2}{2}$ or $\frac{pf^2}{2}$ whichever governs.

$S = \frac{M}{18{,}000}; = \frac{pe^2}{36{,}000} = \frac{pf^2}{36{,}000}$ whichever governs.

$t^2 = \frac{pe^2}{6{,}000}$ or $\frac{pf^2}{6{,}000}$ whichever governs.



Example: Base Slab. Assume column load of 1,500,000 lbs. on 14" @ 342# C. B. Section, on concrete, $f_c = 500$.
Area required = 1,500,000÷500=3,000□". Make slab 54"x56"in size.
$D = 17.56''$ $0.95D = 16.7''$ $B = 16.37''$ $0.8B = 13.1''$
$e = (56.00 - 16.7) \div 2 = 19.7''$ $f = (54.00 - 13.10) \div 2 = 20.5''$ (governs)
$t^2 = \frac{500 \times 20.5^2}{6{,}000} = 35$ $t = \sqrt{35} = 5.92''$. Use 6½" slab.

Example: Single Tier Grillage. Assume same col. size and load; bearing on concrete with $f_c = 500$. With required area of 3,000□", assume size 36"x84". Slab should extend slightly past center of outer beams; assume 30"x32" slab. With same col. dimensions as before, $e = (30 - 16.7) \div 2 = 6.7''$; $f = (32 - 13.1) \div 2 = 9.5''$.

Slab thickness, direction of beams, $t = \sqrt{\frac{Pe^2}{6{,}000WL}} = \sqrt{\frac{1{,}500{,}000 \times 9.5^2}{6{,}000 \times 30 \times 32}} = 4.85''$

Slab thickness across grillage, assuming 5 beams; $t = \sqrt{\frac{6Pl}{nLf}} = \sqrt{\frac{6 \times 1{,}500{,}000 \times 6.7}{5 \times 32 \times 18{,}000}} = 4.57''$. (Use 5".)

M_m @ center of beams = $[P(L_1 - a) \div 8]$ ft. lbs;

$S = \frac{12P(L_1 - a)}{8Fn} = \frac{12 \times 1{,}500{,}000 \times (7 - 2.67)}{8 \times 18{,}000 \times 5} = 108.$ Try 20" @ 65.4# I.

Max. shear @ edge base $= \frac{P}{L_1} \times \frac{L_1 - a}{2}$; $f_s = \frac{P}{L_1} \times \frac{L_1 - a}{2} \times \frac{1}{ndt}$

$= \frac{1{,}500{,}000}{7.00} \times \frac{7.00 - 2.67}{2} \times \frac{1}{5 \times 20 \times .50} = 9{,}300$#□". (All. 12,000)

Req'd. web for buckling; $t_1 = \frac{P}{n(12a + \frac{1}{2}d)f_b}$ and $f_b = \frac{P}{n(12a + \frac{1}{2}d)t_1} = \frac{1{,}500{,}000}{5(12 \times 2.67 + 10)\,0.50} = 14{,}300$#/□"

NOMENCLATURE

a = Loaded portion beam, in feet.
d = Depth of beam, in.
F = Bending value.
f_b = Unit web buckling.
f_s = Unit web shear.
l = Dist., point M_M to outer beam.
L_1 = Length grillage beam, in feet.
p = Unit pressure.
P = Column load.
n = No. of beams.
t = Slab thickness, in.
t_1 = Beam web thick.
S = Section Modulus.

Most authorities disregard buckling when grillage is encased in concrete. If it is considered, the beam in example should be refigured. Try 20" @ 70# I, with web 0.567". The formula then gives value of $f_b = 12{,}600$; the 20" @ 70# I is good for 12,723#/□".

Example: Double Tier Grillage. Assume same load, col. size, etc., as before. Area = 3,000□"; make 54"x56" size. Assume base slab 24x26; $e = (24 - 16.6) \div 2 = 3.7''$; $f = (26 - 13.1) \div 2 = 6.45''$.

For "e", $t = \sqrt{\frac{1{,}500{,}000 \times 6 \times 3.7}{4 \times 26 \times 18{,}000}} = 4.21''$. For "f", $t = \sqrt{\frac{1{,}500{,}000 \times 6.45^2}{6{,}000 \times 24 \times 26}} = 4.08''$. Use 4½"

Top tier: 4 beams 56" long; $S = \frac{1{,}500{,}000 \times (56 - 26)}{8 \times 18{,}000 \times 4} = 78.2.$ Try 4-15" @ 60.8# I.

Buckling: $\frac{1{,}500{,}000}{(26 + 7.5) \times 4 \times 0.59} = 19{,}000$ too high; try $\frac{1{,}500{,}000}{(26 + 7.5) \times 4 \times 0.77} = 14{,}500$; Use 4-15" @ 70# I.

Shear @ edge slab: $\frac{1{,}500{,}000 \times [(56 - 26) \div 2]}{56 \times 4 \times 15 \times .77} = 8{,}700.$ (Allow. 12,000)

Bottom tier: 54 — 28.68 = 25.32. $S = \frac{1{,}500{,}000 \times 25.32}{8 \times 18{,}000 \times 8} = 33.0.$ Try 8-12" @ 35# I.

Buckling: $\frac{1{,}500{,}000}{(28.68 + 6) \times .428 \times 8} = 12{,}600$; OK. Shear, edge upper tier: $\frac{1{,}500{,}000}{54 \times 12 \times 428} = 5{,}400$ OK.

DESIGN DATA FOR COLUMN SLABS AND GRILLAGES

Masonry Unit Pressures:	Sq. In.
Common brick, lime mortar	100 lbs.
Rubble masonry, lime mortar	150
Common brick, Port. cem. mortar	200
Rubble masonry, Port. cem. mortar	200
Hard brick, Port. cem. mortar	250
Sandstone, Port. cem. mortar	400
Limestone, Port. cem. mortar	500
Concrete, 2,000 lb., 28 day	600
Granite, Port. cem. mortar	800

All column base slabs 4″ thick or less may be straightened in press. Slabs thicker than 4″ should be machined. All slabs over 2½″ thick are flame cut to size.

Sizes of slabs shown are those that are readily obtainable. Sizes up to 120″x120″x12″ may be secured by arrangement with the mills.

The information given below for staandard beams and channels is to facilitate grillage design. The standard beam, with its relatively narrow flange and thick web, is better fitted for use in grillages under ordinary conditions than is the wide flange beam. Where exceptionally thick webs are needed to resist shearing or buckling stresses, two channels may be used, back to back; additional plates may be placed between, if necessary.

Values of t^2 for Various Slab Thicknesses

t^2	Thickness			t^2	Thickness			t^2	Thickness		
	Rough	Machined			Rough	Machined			Rough	Machined	
		Top Only	Both Faces			Top Only	Both Faces			Top Only	Both Faces
1.00	1			19.14	5		4⅜	54.39	8		7⅜
1.56	1¼			22.56	5	4¾		60.06	8	7¾	
2.25	1½			23.77	5½		4⅞	70.14	9		8⅜
4.00	2			27.56	5½	5¼		76.56	9	8¾	
6.25	2½			28.90	6		5⅜	87.89	10		9⅜
9.00	3			33.06	6	5¾		95.06	10	9¾	
12.25	3½			34.51	6½		5⅞	107.64	11		10⅜
16.00	4			39.06	6½	6¼		115.56	11	10¾	
15.02	4½		3⅞	40.64	7		6⅜	129.39	12		11⅜
18.06	4½	4¼		45.56	7	6¾		138.06	12	11¾	

Available Sizes of Slabs

Width	t	Width	t	Width	t	Width	t
14	1¼	28	3	44	5½	60	7
14	1½	28	3½	44	6	60	8
16	1½	28	4	48	5½	66	8
16	2	32	3½	48	6	66	9
20	2	32	4	48	6½	72	9
20	2½	36	4	52	6	72	10
20	3	36	4½	52	6½		
24	2	40	4½	56	6½		
24	2½	40	5	56	7		
24	3	44	5	56	8		

STANDARD BEAMS

Size	Wt. per Foot	Section Mod'us 1-1	Flange Width Inches	Web Thick.	Max. Moment Ft. Lbs.	Total Web Shear	Unit Web Buc'ing
8″	18.4	14.2	4.000	.270	21300	25920	13925
	20.5	15.1	4.079	.349	22650	33500	15000
	23.0	16.0	4.171	.441	24000	42340	15000
	25.5	17.0	4.262	.532	25500	51070	15000
9″	21.8	18.9	4.330	.290	28350	31320	13626
	25.0	20.3	4.437	.397	30450	42880	15000
	30.0	22.5	4.601	.561	33750	60590	15000
	35.0	24.7	4.764	.724	37050	78190	15000
10″	25.4	24.4	4.660	.310	36600	37200	13364
	30.0	26.7	4.797	.447	40050	53640	15000
	35.0	29.2	4.944	.594	43800	71280	15000
	40.0	31.6	5.091	.741	47400	88920	15000
12″	31.8	36.0	5.000	.350	54000	50400	12933
	35.0	37.8	5.078	.428	56700	61630	14263
	40.8	44.8	5.250	.460	67200	66240	14672
	45.0	47.3	5.355	.565	70950	81360	15000
	50.0	50.3	5.477	.687	75450	98930	15000
	55.0	53.2	5.600	.810	79800	116640	15000
15″	42.9	58.9	5.500	.410	88350	73800	12446
	45.0	60.5	5.542	.452	90750	81360	13166
	50.0	64.2	5.640	.550	96300	99000	14423
	55.0	67.8	5.738	.648	101700	116640	15000
	60.8	81.2	6.000	.590	121800	106200	14810
	65.0	84.3	6.082	.672	126450	120960	15000
	70.0	87.9	6.180	.770	131850	138600	15000
	75.0	91.6	6.278	.868	137400	156240	15000
	81.3	105.2	6.400	.800	157800	144000	15000
	85.0	107.9	6.472	.872	161850	156960	15000
	90.0	111.6	6.570	.970	167400	174600	15000
	95.0	115.3	6.668	1.068	172950	192240	15000
	100.0	119.0	6.767	1.167	178500	210060	15000
18″	54.7	88.4	6.000	.460	132600	99360	11917
	60.0	93.1	6.087	.547	139650	118150	13226
	65.0	97.5	6.169	.629	146250	135860	14140
	70.0	101.9	6.251	.711	152850	153580	14832
	75.6	126.9	7.000	.560	190350	120960	13389
	80.0	130.8	7.072	.632	196200	136510	14169
	85.0	135.2	7.154	.714	202800	154220	14854
	90.0	139.6	7.236	.796	209400	171940	15000
20″	65.4	116.9	6.250	.500	175350	120000	11739
	70.0	121.4	6.317	.567	182100	136080	12723
	75.0	126.3	6.391	.641	189450	153840	13589
	81.4	146.6	7.000	.600	219900	144000	13135

STANDARD BEAMS (CONT'D)

Size	Wt. per Foot	Section Mod'us 1-1	Flange Width Inches	Web Thick.	Max. Moment Ft. Lbs.	Total Web Shear	Unit Web Buc'ing
20″ Con.	85.0	150.2	7.053	.653	225300	156720	13713
	90.0	155.0	7.126	.726	232500	174240	14366
	95.0	160.0	7.200	.800	240000	192000	14896
	100.0	164.8	7.273	.873	247200	209520	15000
24″	79.9	173.9	7.000	.500	260850	144000	10181
	85.0	180.0	7.063	.563	270000	162140	11209
	90.0	185.8	7.124	.624	278700	179710	12055
	95.0	191.8	7.186	.686	287700	197570	12784
	100.0	197.6	7.247	.747	296400	215140	13393
	105.9	234.3	7.875	.625	351450	180000	12068
	110.0	239.1	7.925	.675	358650	194400	12664
	115.0	245.0	7.987	.737	367550	212260	13300
	120.0	250.9	8.048	.798	376350	229820	13829

STANDARD CHANNELS

Size	Wt. per Foot	Section Mod'us 1-1	Flange Width Inches	Web Thick.	Max. Moment Ft. Lbs.	Total Web Shear	Unit Web Buc'ing
8″	11.5	8.1	2.260	.220	12150	21120	12493
	13.75	9.0	2.343	.303	13500	29090	14606
	16.25	9.9	2.435	.395	14850	37920	15000
	18.75	10.9	2.527	.487	16350	46750	15000
	21.25	11.9	2.619	.579	17850	55580	15000
9″	13.4	10.5	2.430	.230	15750	24840	11917
	15.0	11.3	2.485	.285	16950	30780	13509
	20.0	13.5	2.648	.448	20250	48380	15000
	25.0	15.7	2.812	.612	23550	66100	15000
10″	15.3	13.4	2.600	.240	20100	28800	11401
	20.0	15.7	2.739	.379	23550	45480	14609
	25.0	18.1	2.886	.526	27150	63120	15000
	30.0	20.6	3.033	.673	30900	80760	15000
	35.0	23.0	3.180	.820	34500	98400	15000
12″	20.7	21.4	2.940	.280	32100	40320	11165
	25.0	23.9	3.047	.387	35850	55730	13631
	30.0	26.9	3.170	.510	40350	73440	15000
	35.0	29.8	3.292	.632	44700	91010	15000
	40.0	32.8	3.415	.755	49200	108720	15000
15″	33.9	41.7	3.400	.400	62550	72000	12255
	35.0	42.5	3.422	.422	63750	75960	12666
	40.0	46.2	3.520	.520	69300	93600	14091
	45.0	49.8	3.618	.618	74700	111240	15000
	50.0	53.6	3.716	.716	80400	128880	15000
	55.0	57.2	3.814	.814	85800	146520	15000

EXPLANATION—ELEMENTS OF SECTIONS

The NEUTRAL AXIS is the line in the cross section of a beam or column in a state of flexure on which there is neither compression or tension. The neutral axis passes through the center of gravity of the section, for unit stresses less than the elastic limit of the material. For usual structural shapes there are two neutral axès, perpendicular to each other, designated herein as 1-1 about the principal axis, and 2-2 as the lesser.

The MOMENT OF INERTIA, I, is the sum of the products resulting from the multiplying of each of the elementary areas of which the section is composed, by the square of its normal distance from a neutral axis of the section, or from any axis of moments assumed for purposes of calculation.

The section modulus is a more or less abstract quantity. It is used to determine the stress in the extreme fiber of a section, subjected to bending stresses, by dividing the bending moment, found by flexure equations, by the section modulus referred to line of action of the load; both values in like units of measure. The section modulus required for a given section is obtained by dividing the bending stress by the allowable unit stress, both values in like units of measure. Given S, the Section Modulus, the proper section is then obtained from the tables.

The RADIUS OF GYRATION, r, is the normal distance from a neutral axis to the center of gyration—the point where the entire area is considered to be concentrated and to have the same moment of inertia as the actual area. The radius of gyration of a section referred to a neutral axis, or any axis of moments, is equal to the square root of the quotient obtained by dividing the moment of inertia about that axis by the area.

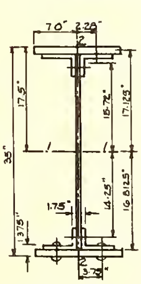
The radius of gyration of a section is used to ascertain the safe load this section will sustain when used in compression, as a strut or column. The unbraced length in inches, of the section in compression, divided by the least radius of gyration, is its ratio of slenderness, *l/r*.

The common relations existing between the properties of any shape of uniform cross section are the following:

$$I = Ar^2 \qquad r = \sqrt{\frac{I}{A}} \qquad S = \frac{I}{n}$$

Compound Sections

1 Web Pl: 33x½; 4 Ls: 6×4×⅝;
2 Flg. Pls: 14×¾



4 Ls: 6×4×⅝
1 Web: 33×½
2 Cors.: 14×⅜

Axis 1-1:

I_1 of 4: 6×4×⅝ Ls = 4×7.5 = 30.00

Az^2 of 4: 6×4×⅝Ls = 4×5.86×15.72² = 5792.46

I_1 of 33×½ Pl. $= 1\times\frac{0.50\times33^3}{12}$ = 1497.38

I_1 of 2: 14×¾ Pl. $= 2\times\frac{14\times75^3}{12}$ = 0.98

Az^2 of 2: 14×¾ Pl = 2×10.50×17.125² = 6158.58

I, Gross Section = 13479.40

Section Modulus $= \frac{13479.40}{17.50}$ = 770.26

Axis 2-2:

I_2 of 4: 6×4×⅝Ls = 4×21.1 = 84.40

Az^2 of 4: 6×4×⅝Ls = 4×5.86×2.28² = 121.85

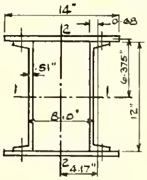
I_2 of 1: 33×½ Pl. $= 1\times\frac{33\times.50^3}{12}$ = 0.34

I_2 of 2: 14×¾ Pls. $= 2\times\frac{0.75\times14^3}{12}$ = 343.00

I, Gross Section = 549.59

Section Modulus $= \frac{549.59}{7}$ = 78.51

Compound Sections



2[s: 12" @ 30#
2 Pls: 14×¾

Axis 1-1:

I_1 of 2: 12" @ 30# [s = 2×161.2 = 322.40

I_1 of 2: 14×¾ Pls $= 2\times\frac{14\times0.75^3}{12}$ = 0.98

Az^2 of 2: 14×¾ Pds = 2×10.5×6.375² = 853.45

I_1, Gross Section = 1176.83

Rad. Gyr. $= \sqrt{\frac{1176.83}{38.58}}$ = 5.52

Axis 2-2:

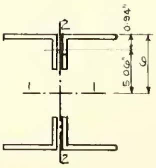
I_2 of 2: 12" @ 30# [s = 2×5.2 = 10.40

Az^2 of 2: 12" @ 30# [s = 2× 8.79×4.17² = 305.70

I_2 of 2: 14×¾ Pls $= 2\times\frac{0.75\times143}{12}$ = 343.00

I_2, Gross Section = 659.10

Rad. Gyr. $= \sqrt{\frac{659.10}{38.58}}$ = 4.13



4 Ls: 6×4×⅜
$\frac{5}{16}$" lacing bars

Axis 1-1:

I_1 of 4: 6×4×⅜Ls = 4×4.9 = 19.60

Az^2 of 4: 6×4×⅜Ls = 4×3.61×5.06² = 369.72

I_1, Gross Section = 389.32

Rad. Gyr. $= \sqrt{\frac{389.32}{14.44}}$ = 5.19

Axis 2-2:

From Tables of radii of gyration for 2 angles placed back to back, Axis 2-2, ⅝" apart, r_{2-2} of 4: 6×4×⅜ Ls = 2.97.

FREQUENTLY USED FORMULAS

The formulas given below are frequently required in structural designing. They are included herein for the convenience of those engineers who have infrequent use for such formulas and hence may find reference necessary. Variation from the standard nomenclature is noted.

BEAMS

Flexural stress at extreme fiber:

$f = Mc/I = M/S$

Flexural stress at any fiber:

$f = My/I$ y = distance from neutral axis to fiber.

Average vertical shear (for maximum see below):

$v = V/A = V/dt$ (for beams and girders)

Horizontal shearing stress at any section A-A:

$v = VQ/Ib$ Q = statical moment about the neutral axis of that portion of the cross-section lying outside of section A-A,
b = width at section A-A

(Intensity of vertical shear is equal to that of horizontal shear acting normal to it at the same point and both are usually a maximum at mid-height of beam.)

Slope and deflection at any point:

$EI\frac{d^2y}{dx^2} = M$ x and y are abscissa and ordinate respectively of a point on the neutral axis, referred to axes of rectangular coordinates through a selected point of support.

(First integration gives slopes; second integration gives deflections. Constants of integration must be determined.)

CONTINUOUS BEAMS

Uniform load:

$$M_a\frac{l_1}{I_1} + 2M_b\left(\frac{l_1}{I_1} + \frac{l_2}{I_2}\right) + M_c\frac{l_2}{I_2} = -\frac{1}{4}\left(\frac{w_1 l_1^3}{I_1} + \frac{w_2 l_2^3}{I_2}\right)$$

Concentrated loads:

$$M_a\frac{l_1}{I_1} + 2M_b\left(\frac{l_1}{I_1} + \frac{l_2}{I_2}\right) + M_c\frac{l_2}{I_2} = -\frac{P_1a_1b_1}{I_1}\left(1 + \frac{a_1}{l_1}\right) - \frac{P_2a_2b_2}{I_2}\left(1 + \frac{b_2}{l_2}\right)$$

Considering any two consecutive spans in any continuous structure:
M_a, M_b, M_c = moments at left, center, and right supports respectively.
l_1 and l_2 = length of left and right spans respectively.
I_1 and I_2 = moment of inertia of left and right spans respectively.
w_1 and w_2 = load per unit of length on left and right spans respectively.
P_1 and P_2 = concentrated loads on left and right spans respectively.
a_1 and a_2 = distance of concentrated loads from left support in left and right spans respectively.
b_1 and b_2 = distance of concentrated loads from right support in left and right spans respectively.

The above equations are for beams with variable moment of inertia continuous over three or more supports. By writing such an equation for each successive pair of spans and introducing the known values of end moments, all other moments can be found.

COLUMNS

Concentrically loaded:

$f = P/A$

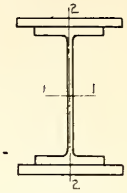
Eccentrically loaded:

$f = P/A + Mc/I$. Bending in plane of principal axis. Deflection not considered.

$= \frac{P}{A}(1 + ec/r^2)$ e = eccentricity of load.

WIDE FLANGE BEAMS WITH COVER PLATES

PROPERTIES AXIS 1-1

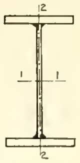


SIZE BEAM	SIZE COVER PLATE	GROSS WEIGHT	GROSS AREA	Axis 1-1 I	Axis 1-1 S	Axis 1-1 r	Axis 2-2 r
30″ @ 108	7x5/16	122.9	36.15	5454	358	12.3	2.06
	7x⅜	125.9	37.02	5659	370	12.3	2.05
	8x⅜	128.4	37.77	5827	381	12.4	2.10
	7/16	131.8	38.77	6064	395	12.5	2.11
	½	135.2	39.77	6300	409	12.6	2.11
	9/16	138.6	40.77	6538	423	12.7	2.12
	⅝	142.0	41.77	6778	436	12.7	2.12
	9x⅜	131.0	38.52	6000	393	12.4	2.16
	7/16	134.8	39.65	6265	408	12.5	2.18
	½	138.6	40.77	6530	424	12.6	2.19
	9/16	142.4	41.90	6796	439	12.7	2.20
	⅝	146.3	43.02	7070	455	12.8	2.21
	¾	153.9	45.27	7614	486	13.0	2.24
	⅞	161.6	47.52	8170	518	13.1	2.25
30″ @ 172	8x⅜	192.6	56.65	9264	605	12.8	3.20
	7/16	196.0	57.65	9500	618	12.8	3.19
	½	199.4	58.65	9737	631	12.9	3.18
	⅝	206.2	60.65	10217	657	13.1	3.15
	¾	213.0	62.65	10795	688	13.1	3.13
	9x⅜	195.2	57.41	9437	616	12.8	3.21
	7/16	199.0	58.53	9703	631	12.9	3.21
	½	202.8	59.65	9968	646	12.9	3.20
	9/16	206.6	60.77	10236	660	13.1	3.19
	⅝	210.5	61.91	10510	675	13.1	3.18
	¾	218.1	64.15	11056	705	13.1	3.16
	⅞	225.8	66.41	11616	735	13.2	3.14
	1	233.4	68.65	12184	764	13.3	3.13
	10x⅜	197.7	58.15	9606	627	12.8	3.24
	7/16	202.0	59.41	9905	644	12.9	3.23
	½	206.2	60.65	10199	660	12.9	3.22
	⅝	214.7	63.15	10799	694	13.0	3.21
	¾	223.2	65.65	11408	727	13.2	3.20
	⅞	231.7	68.15	12207	772	13.4	3.19
	1	240.2	70.65	12681	796	13.4	3.18
33″ @ 130	7x5/16	145.0	42.64	7922	470	13.6	2.26
	⅜	148.0	43.52	8167	483	13.7	2.26
	8x⅜	150.5	44.26	8380	495	13.6	2.29
	7/16	153.9	45.26	8668	510	13.8	2.30
	½	157.3	46.26	8957	525	13.9	2.30
	9/16	160.7	47.26	9248	540	13.9	2.30
	⅝	164.1	48.26	9542	556	14.0	2.29
	9x⅜	153.1	45.02	8593	508	13.8	2.34
	7/16	156.9	46.14	8915	525	13.9	2.35
	½	160.7	47.26	9239	542	13.9	2.35
	9/16	164.5	48.38	9566	559	14.0	2.36
	⅝	168.4	49.52	9900	576	14.1	2.36
	¾	176.0	51.76	10564	611	14.2	2.38
	⅞	183.7	54.02	11249	646	14.4	2.38
33″ @ 200	8x⅜	220.3	64.79	12719	754	14.0	3.34
	7/16	223.7	65.79	13005	768	14.0	3.33
	½	227.1	66.79	13293	782	14.1	3.32
	⅝	233.9	68.79	13874	810	14.2	3.29
	¾	240.7	70.79	14464	838	14.3	3.27
	9x⅜	222.9	65.55	12931	766	14.0	3.35
	7/16	226.7	66.67	13250	782	14.1	3.34
	½	230.5	67.79	13573	798	14.1	3.31
	⅝	238.2	70.05	14230	831	14.2	3.31
	¾	245.8	72.29	14891	863	14.3	3.29
	⅞	253.5	74.55	15571	896	14.4	3.27
	1	261.1	76.79	16251	929	14.5	3.25
	1⅛	268.7	79.05	16941	961	14.6	3.24
	10x⅜	225.4	66.29	13137	778	14.0	3.37
	7/16	229.7	67.55	13497	797	14.1	3.36
	½	233.9	68.79	13854	815	14.2	3.36
	⅝	242.4	71.29	14580	851	14.2	3.34
	¾	250.9	73.79	15318	888	14.4	3.32
	⅞	259.4	76.29	16071	925	14.5	3.31
	1	267.9	78.79	16830	962	14.6	3.30

SIZE BEAM	SIZE COVER PLATE	GROSS WEIGHT	GROSS AREA	Axis 1-1 I	Axis 1-1 S	Axis 1-1 r	Axis 2-2 r
36″ @ 150	7x5/16	165.0	48.54	10444	573	14.6	2.35
	⅜	168.0	49.42	10737	587	14.7	2.34
	8x⅜	170.5	50.16	10980	600	14.7	2.37
	7/16	173.9	51.16	11316	616	14.8	2.37
	½	177.3	52.16	11653	633	14.9	2.37
	9/16	180.7	53.16	11993	649	15.0	2.37
	⅝	184.1	54.16	12336	665	15.1	2.37
	9x⅜	173.1	50.92	11229	614	14.9	2.41
	7/16	176.9	52.04	11605	632	14.9	2.41
	½	180.7	53.16	11983	650	15.0	2.42
	9/16	184.5	54.28	12364	669	15.1	2.42
	⅝	188.4	55.42	12754	688	15.2	2.42
	¾	195.7	57.56	13529	725	15.3	2.43
	⅞	203.7	59.92	14325	762	15.5	2.44
36″ @ 230	8x⅜	250.7	73.73	16960	926	15.1	3.50
	7/16	254.1	74.73	17297	941	15.2	3.49
	½	257.5	75.73	17639	956	15.3	3.47
	9/16	260.9	76.73	17976	972	15.3	3.46
	⅝	264.3	77.73	18319	987	15.4	3.45
	10x⅜	255.8	75.23	17453	953	15.2	3.52
	7/16	260.1	76.49	17877	973	15.3	3.51
	½	264.3	77.73	18297	992	15.3	3.50
	9/16	268.6	78.99	18726	1012	15.3	3.49
	⅝	272.8	80.23	19152	1032	15.4	3.49
	¾	281.3	82.73	20077	1074	15.6	3.47
	⅞	289.8	85.23	20900	1111	15.6	3.45
	1	298.3	87.73	21790	1150	15.7	3.44
	12x⅜	260.9	76.73	17946	980	15.2	3.57
	7/16	267.7	78.23	18450	1004	15.3	3.57
	½	271.1	79.73	18959	1038	15.4	3.57
	⅝	281.3	82.73	19984	1077	15.5	3.56
	¾	291.5	85.73	21023	1125	15.7	3.56
	⅞	301.7	88.73	22083	1174	15.8	3.56
	1	311.9	91.73	23151	1222	15.9	3.56
36″ @ 300	8x⅜	320.2	94.17	22355	1194	15.4	3.65
	7/16	323.6	95.17	22707	1208	15.4	3.64
	½	327.0	96.17	23061	1223	15.5	3.63
	9/16	330.4	97.17	23417	1238	15.5	3.62
	⅝	333.8	98.17	23776	1253	15.5	3.61
	¾	340.6	100.17	24500	1282	15.6	3.59
	⅞	347.4	102.17	25239	1312	15.8	3.57
	10x⅜	325.3	95.67	22871	1221	15.4	3.67
	7/16	329.6	96.93	23314	1240	15.5	3.65
	½	333.8	98.17	23753	1259	15.5	3.65
	9/16	338.1	99.43	24202	1279	15.6	3.64
	⅝	342.3	100.67	24647	1298	15.7	3.63
	¾	350.8	103.17	25553	1337	15.8	3.62
	⅞	359.3	105.67	26476	1377	15.9	3.61
	1	367.8	108.17	27406	1416	15.9	3.59
	1⅛	376.3	110.67	28347	1455	16.0	3.57
	1¼	384.8	113.17	29299	1494	16.1	3.55
	12x⅜	330.4	97.17	23387	1249	15.5	3.70
	7/16	335.5	98 67	23915	1272	15.5	3.70
	½	340.6	100.17	24446	1296	15.5	3.70
	9/16	345.7	101.67	24981	1320	15.5	3.69
	⅝	350.8	103.17	25519	1344	15.5	3.69
	11/16	355.9	104.67	26060	1366	15.6	3.69
	¾	361.0	106.17	26605	1392	15.8	3.69
	13/16	366.1	107.67	27161	1417	15.9	3.68
	⅞	371.2	109.17	27713	1441	15.9	3.68
	15/16	376.3	110.67	28269	1465	15.9	3.68
	1	381.4	112.17	28829	1489	16.0	3.67
	1⅛	391.6	115.17	29958	1538	16.1	3.66
	1¼	401.8	118.17	31101	1586	16.2	3.66
	1⅜	412.0	121.17	32272	1636	16.2	3.66
	1½	422.2	124.17	33444	1684	16.3	3.65
	1⅝	432.4	127.17	34631	1729	16.4	3.65
	1¾	442.6	130.17	35828	1782	16.5	3.65

3-PLATE, WELDED GIRDERS

MOMENT OF INERTIA—AXIS 1-1



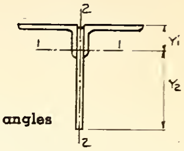
WEB PLATE	FLANGE THICKNESS	I_{1-1} for Flange Width Given					WEB PLATE	FLANGE THICKNESS	I_{1-1} for Flange Width Given				
		10″	12″	14″	16″	18″			16″	18″	20″	22″	24″
36 x 3/8	½	4788	5455	6121	6787	7453	84 x 1/2	1¼	97360	106443	115526	124608	133691
	¾	6521	7533	8546	9558	10571		1½	112428	123394	134361	145327	156294
	1	8305	9674	11043	12412	13782		1¾	127629	140496	153362	166229	179096
	1¼	10129	11863	13597	15331	17065		2	143053	157848	172643	187437	202232
	1½	12010	14121	16231	18342	20452		2¼	158598	175336	192074	208812	225550
38 x 3/8	½	5421	6162	6903	7644	8385	90 x 1/2	1¼	113627	124034	134440	144847	155254
	¾	7344	8469	9595	10721	11846		1½	130850	143410	155970	168529	181089
	1	9322	10843	12364	13885	15407		1¾	148217	162947	177677	192407	207137
	1¼	11342	13267	15192	17118	19043		2	165820	182751	199682	216612	233543
	1½	13422	15764	18105	20447	22788		2¼	183553	202700	221848	240995	260142
40 x 3/8	½	6101	6921	7741	8561	9381	96 x 1/2	1½	137340	149899	162459	175018	187578
	¾	8225	9470	10715	11960	13205		1¾	170622	187341	204061	220781	237501
	1	10407	12088	13769	15450	17132		2	190549	209760	228971	248181	267392
	1¼	12633	14759	16886	19012	21139		2¼	210614	232333	254052	275770	297489
	1½	14922	17507	20091	22676	25260		2½	230951	255211	279472	303733	327994
42 x 3/8	½	6831	7734	8637	9540	10443	102 x 5/8	1½	183827	199896	215966	232035	248105
	¾	9166	10536	11906	13276	14646		1¾	205953	224788	243624	262459	281294
	1	11562	13411	15260	17110	18959		2	228348	249983	271618	293252	314887
	1¼	14004	16341	18679	21017	23355		2¼	250889	275341	299793	324246	348698
	1½	16512	19352	22191	25031	27870		2½	251877	276453	301029	325604	350180
48 x 7/16	¾	12941	14723	16505	18287	20068	108 x 5/8	1½	209502	227488	245475	263461	281448
	1	16039	18440	20841	23242	25644		1¾	234224	255301	276378	297455	318532
	1¼	19189	22220	25251	28283	31314		2	259231	283434	307637	331839	356042
	1½	22414	26091	29767	33444	37120		2¼	284392	311739	339087	366435	393783
	1¾	25689	30020	34352	38683	43015		2½	309857	340387	370918	401449	431980
54 x 7/16	¾	16978	19226	21473	23721	25968	114 x 5/8	1½	237256	257267	277279	297290	317302
	1	20868	23893	26918	29943	32969		1¾	264719	288163	311608	335052	358496
	1¼	24816	28631	32446	36261	40076		2	292481	319396	346311	373225	400140
	1½	28848	33470	38091	42713	47334		2¼	320406	350811	381216	411621	442026
	1¾	32936	38375	43814	49253	54692		2½	348651	382586	416522	450458	484394
60 x 7/16	1	26482	30203	33924	37646	41367	120 x 3/4	1½	285156	307300	329445	351589	373734
	1¼	31318	36006	40695	45383	50072		1¾	315503	341441	367379	393317	419254
	1½	36247	41922	47596	53271	58945		2	346165	375936	405707	435477	465248
	1¾	41237	47910	54582	61255	67927		2¼	376997	410622	444247	477871	511496
	2	46328	54019	61710	69400	77091		2½	408167	445688	483208	520729	558250
66 x 7/16	1	32928	37418	41907	46396	50886	126 x 3/4	1½	320108	344493	368879	393264	417650
	1¼	38743	44395	50047	55699	61351		1¾	353483	382041	410598	439155	467713
	1½	44659	51495	58330	65166	72001		2	387189	419960	452731	485501	518272
	1¾	50651	58684	66718	74752	82785		2¼	421073	458079	495086	532092	569098
	2	56735	65986	75237	84487	93738		2½	455269	496549	537830	579111	620391
72 x 1/2	1	42199	47528	52857	58186	63516	132 x 3/4	1½	357624	384358	411093	437827	464562
	1¼	49081	55786	62492	69198	75904		1¾	394172	425475	456778	488080	519383
	1½	56074	64179	72283	80389	88492		2	431065	466980	502895	538809	574724
	1¾	63140	72657	82175	91692	101210		2¼	468145	508695	549244	589794	630344
	2	70325	81280	92235	103189	114144		2½	505595	550825	596056	641287	686518
78 x 1/2	1	50980	57221	63462	69703	75945	144 x 3/4	1½	440676	472432	504189	535945	567702
	1¼	59020	66869	74718	82568	90417		1¾	484000	521172	558344	595516	632688
	1½	67180	76662	86143	95625	105106		2	527701	570336	612971	655605	698240
	1¾	75419	86548	97677	108806	119935		2¼	571605	619727	667850	715973	764095
	2	83786	96589	109392	122194	134997		2½	615911	669571	723232	776893	830554

CHORD SECTION

2 ANGLES AND ONE PLATE

PROPERTIES

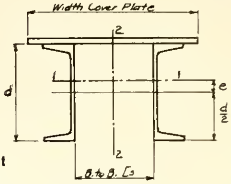
$S_1 = I/y_1$
$S_2 = I/y_2$



¼" from back of angles to edge of plate.

SIZE PLATE	SIZE ANGLES	GROSS AREA	STRUT AREA	Axis 1-1					AXIS 2-2
				I	S_1	S_2	r_1	y_1	r_2
8x¼	3x2½x¼	4.62	3.90	26.7	12.1	4.4	2.41	2.21	1.06
	4x3 x¼	5.38	4.75	28.9	14.1	4.7	2.32	2.05	1.48
8x5/16	3x2½x¼	5.12	4.53	31.3	13.0	5.4	2.47	2.41	1.02
	5/16	5.74	5.15	33.1	14.8	5.5	2.40	2.23	1.08
	4x3 x¼	5.88	5.41	33.7	15.1	5.6	2.39	2.23	1.44
	5/16	6.68	6.21	35.7	17.3	5.8	2.31	2.07	1.51
10x¼	3x2½x¼	5.12	3.90	49.3	17.0	6.7	3.10	2.90	1.01
	5/16	5.74	4.58	52.2	19.6	6.9	3.02	2.68	1.06
	4x3 x¼	5.88	4.75	52.8	19.9	7.0	3.00	2.66	1.42
	5/16	6.68	5.56	55.7	22.8	7.1	2.89	2.45	1.49
10x5/16	3x2½x¼	5.74	4.53	57.5	18.3	8.1	3.16	3.15	0.96
	5/16	6.36	5.15	61.0	20.9	8.3	3.10	2.92	1.02
	4x3 x¼	6.50	5.41	61.8	21.3	8.4	3.08	2.91	1.37
	5/16	7.30	6.21	65.4	24.4	8.6	2.99	2.68	1.45
	⅜	8.09	6.99	68.2	27.2	8.8	2.91	2.51	1.50
	5x3½x5/16	8.25	7.23	69.2	27.6	8.9	2.90	2.51	1.87
	⅜	9.23	8.21	72.3	30.8	9.2	2.80	2.35	1.94
10x⅜	3x2½x5/16	6.99	5.91	69.2	22.2	9.7	3.15	3.13	0.99
	⅜	7.59	6.51	72.4	24.4	9.9	3.09	2.96	1.06
	4x3 x5/16	7.93	6.99	74.4	25.8	10.1	3.06	2.88	1.40
	⅜	8.71	7.77	77.7	28.8	10.3	2.99	2.70	1.46
	5x3½x5/16	8.87	8.03	78.7	29.1	10.4	2.98	2.70	1.82
	⅜	9.85	9.01	82.3	32.5	10.7	2.89	2.53	1.89
12x¼	3x2½x¼	5.62	3.90	81.2	22.2	9.5	3.80	3.65	0.96
	5/16	6.24	5.52	86.2	25.6	9.7	3.73	3.36	1.02
	4x3 x¼	6.38	5.06	87.0	26.2	9.7	3.70	3.33	1.36
	5/16	7.18	5.56	92.1	30.2	10.0	3.58	3.05	1.40
	5x3½x5/16	8.12	6.56	96.8	34.0	10.3	3.45	2.84	1.86
	⅜	9.10	7.54	100.8	38.3	10.5	3.33	2.63	1.93
12x5/16	3x2½x¼	6.37	4.53	94.7	24.0	11.4	3.86	3.95	0.92
	5/16	6.99	5.15	100.8	27.5	11.7	3.80	3.67	0.98
	4x3 x¼	7.13	5.41	101.7	28.0	11.8	3.78	3.64	1.31
	5/16	7.93	6.21	108.0	32.1	12.2	3.69	3.36	1.39
	⅜	8.71	6.99	112.9	36.0	12.4	3.60	3.14	1.45
	5x3½x5/16	8.87	7.23	113.4	36.1	12.4	3.57	3.14	1.81
	⅜	9.85	8.21	118.8	40.8	12.7	3.47	2.91	1.87
12x⅜	4x3 x5/16	8.68	6.99	122.7	34.0	14.2	3.76	3.61	1.34
	⅜	9.46	7.77	128.4	38.0	14.5	3.68	3.38	1.40
	5x3½x5/16	9.62	8.03	129.5	38.4	14.6	3.67	3.37	1.75
	⅜	10.60	9.01	135.7	43.1	14.9	3.58	3.15	1.83
	7/16	11.56	9.97	140.5	47.3	15.1	3.49	2.97	1.89
	6x4 x⅜	11.72	10.31	142.0	47.7	15.3	3.48	2.98	2.26
	7/16	12.86	11.45	147.0	52.3	15.6	3.38	2.81	2.33
12x7/16	4x3 x⅜	10.21	8.68	143.1	39.9	16.5	3.74	3.59	1.37
	7/16	10.99	9.46	148.7	43.7	16.8	3.68	3.40	1.43
	5x3½x⅜	11.35	9.93	151.2	45.1	17.0	3.65	3.35	1.78
	7/16	12.31	10.89	157.1	49.6	17.3	3.57	3.17	1.85
	½	13.25	11.83	161.7	53.4	17.5	3.49	3.03	1.91
	6x4 x⅜	12.47	11.27	158.7	49.9	17.5	3.57	3.18	2.20
	7/16	13.61	12.41	164.4	54.8	17.8	3.48	3.00	2.28
	½	14.75	13.55	169.0	59.1	18.0	3.39	2.86	2.35
12x½	4x3 x7/16	11.74	10.49	163.6	45.5	19.0	3.74	3.60	1.40
	½	12.50	11.25	168.4	49.1	19.1	3.67	3.43	1.46
	9/16	13.24	11.99	173.1	52.5	19.3	3.62	3.30	1.50
	5x3½x7/16	13.06	11.93	172.9	51.6	19.4	3.64	3.35	1.81
	½	14.00	12.87	177.9	55.6	19.7	3.57	3.20	1.88
	9/16	14.94	13.81	182.7	59.5	19.9	3.50	3.07	1.93
	6x4 x7/16	14.36	13.48	180.9	57.1	19.9	3.55	3.17	2.24
	½	15.50	14.62	186.5	61.5	20.2	3.47	3.03	2.31
	9/16	16.62	15.74	191.0	65.9	20.4	3.39	2.90	2.36
14x⅜	5x3½x⅜	11.35	9.01	207.5	54.3	19.9	4.28	3.82	1.77
	7/16	12.31	9.97	215.3	59.8	20.2	4.18	3.60	1.83
	½	13.25	10.91	221.2	64.7	20.4	4.09	3.42	1.89
	6x4 x⅜	12.47	10.31	216.7	60.2	20.4	4.17	3.60	2.19
	7/16	13.61	11.45	224.7	66.3	20.7	4.06	3.39	2.26
	½	14.75	12.59	230.9	71.7	20.9	3.96	3.22	2.33
	7x4 x⅜	13.21	11.05	225.0	66.0	20.8	4.13	3.41	2.66
	7/16	14.49	12.33	232.6	72.9	21.0	4.01	3.19	2.74
	½	15.75	13.59	239.1	78.9	21.3	3.90	3.03	2.82
	8x4 x½	16.75	14.59	246.2	86.1	21.6	3.83	2.86	3.31
14x½	5x3½x½	15.00	12.88	273.5	70.8	25.3	4.27	3.86	1.81
	⅝	16.84	14.72	286.2	80.3	26.7	4.13	3.57	1.91
	6x4 x½	16.50	14.63	285.0	78.1	26.7	4.16	3.65	2.24
	⅝	18.72	16.85	298.8	89.5	27.5	4.00	3.35	2.35
	¾	20.88	19.01	308.8	98.4	27.7	3.84	3.14	2.44
	7x4 x½	17.50	15.63	294.3	85.0	27.2	4.11	3.45	2.71
	⅝	19.96	18.09	309.7	97.5	27.9	3.94	3.17	2.85
	¾	22.38	20.51	319.8	104.5	27.5	3.73	2.97	2.94
	8x4 x½	18.50	16.63	305.4	93.2	27.8	4.06	3.28	3.19
	⅝	21.22	19.35	319.0	103.2	28.3	3.88	3.00	3.33
	¾	23.88	22.01	329.5	118.0	28.7	3.72	2.79	3.44
16x⅜	5x3½x⅜	12.10	9.01	299.6	66.4	25.5	4.98	4.52	1.70
	½	14.00	10.91	320.9	79.0	26.3	4.79	4.06	1.84
	6x4 x⅜	13.22	10.31	312.9	73.1	26.0	4.85	4.26	2.12
	½	15.50	12.59	334.4	87.9	26.8	4.65	3.80	2.28
	7x4 x⅜	13.96	11.05	324.5	80.5	26.5	4.82	4.04	2.59
	½	16.50	13.59	346.1	96.5	27.3	4.58	3.59	2.75
	8x4 x7/16	16.12	13.21	347.4	96.9	27.4	4.65	3.59	3.16
	½	17.50	14.59	356.7	105.0	27.6	4.52	3.39	3.25
	9/16	18.86	15.95	365.0	113.5	28.0	4.41	3.22	3.31
	⅝	20.22	17.31	371.5	120.5	28.2	4.29	3.09	3.38
16x½	6x4 x½	17.50	14.63	412.1	95.6	34.6	4.85	4.31	2.17
	⅝	19.72	16.85	433.5	109.0	35.4	4.69	3.96	2.28
	7x4 x½	18.50	15.63	427.6	104.5	35.2	4.81	4.09	2.64
	⅝	20.96	18.09	449.2	121.0	35.8	4.63	3.74	2.78
	¾	23.38	20.51	464.7	133.0	36.4	4.46	3.49	2.88
	8x4 x½	19.50	16.63	441.8	113.5	35.8	4.76	3.89	3.11
	⅝	22.22	19.35	462.7	130.5	36.5	4.58	3.55	3.26
	¾	24.88	22.01	478.7	145.0	37.0	4.38	3.30	3.37
	8x6 x½	21.50	19.31	445.1	112.0	36.4	4.56	3.99	3.58
	⅝	24.72	21.35	468.4	126.5	37.3	4.35	3.70	3.74
	¾	27.88	25.51	487.4	141.0	38.4	4.18	3.48	3.87

CHORD SECTIONS
2-CHANNELS AND 1-PLATE
PROPERTIES
1946 SIMPLIFIED LIST



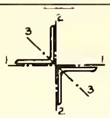
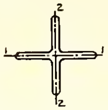
† Exceeds 40t

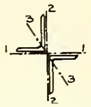
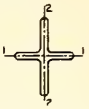
* Limited by 16t

[	SIZE COVER PLATE	AREA	e	Axis 1-1		Axis 2-2			b to b where $I_2 = I_1$
				I_1	r_1	b to b = Pl − 2[s − ⅛″			
						b to b	I_2	r_2	
5″ @ 6.7#	8x¼	5.90	.89	23.9	2.01	4⅜	39.6	2.59	2½
	5/16	6.40	1.04	25.6	2.00	4⅜	42.2	2.57	2½
	10x¼	6.40	1.03	25.2	1.98	6⅜	74.5	3.41	⅞
	5/16	7.03	1.18	27.2	1.97	6⅜	79.7	3.36	0
	12x¼	6.90	1.14	26.5	1.96	†8⅜	122.1	4.22	*1¾
	5/16	7.65	1.30	28.4	1.92	8⅜	131.1	4.14	0
5″ @ 9.0#	8x¼	7.26	.72	27.6	1.95	4⅛	45.9	2.51	2½
	5/16	7.76	.86	29.6	1.95	4⅛	48.4	2.50	2⅜
	10x¼	7.76	.84	29.3	1.94	6⅛	88.0	3.37	1⅜
	5/16	8.39	.99	31.5	1.94	6⅛	93.3	3.34	¾
	12x¼	8.26	.95	30.8	1.91	†8⅛	145.7	4.18	*1¾
	5/16	9.01	1.11	33.1	1.91	8⅛	154.7	4.15	0
6″ @ 8.2#	10x¼	7.28	1.07	42.0	2.40	6⅛	83.5	3.39	3
	5/16	7.91	1.25	44.9	2.38	6⅛	88.8	3.35	2¾
	12x¼	7.78	1.20	44.0	2.38	†8⅛	137.7	4.21	1¼
	5/16	8.53	1.39	47.0	2.34	8⅛	146.7	4.15	0
	14x5/16	9.16	1.51	48.9	2.31	10⅛	221.7	4.92	*1¾
	⅜	10.03	1.67	51.5	2.26	10⅛	236.0	4.86	0
6″ @ 10.5#	10x¼	8.64	.90	47.6	2.35	5⅞	94.8	3.30	3
	5/16	9.27	1.06	51.1	2.35	5⅞	100.1	3.29	2⅞
	12x¼	9.14	1.02	49.9	2.34	†7⅞	158.2	4.17	*1¾
	5/16	9.89	1.20	53.4	2.32	7⅞	167.2	4.12	1⅛
	14x5/16	10.52	1.31	55.9	2.30	9⅞	254.3	4.91	*1¾
	⅜	11.39	1.47	59.1	2.28	9⅞	268.6	4.86	0
6″ @ 13.0#	10x5/16	10.75	.92	56.8	2.30	5⅝	112.8	3.24	2⅞
	⅜	11.37	1.05	60.3	2.30	5⅝	118.0	3.23	2¾
	12x5/16	11.37	1.04	59.8	2.30	7⅝	190.1	4.09	1½
	⅜	12.12	1.18	63.7	2.29	7⅝	199.1	4.05	1
	14x5/16	12.00	1.15	62.5	2.28	9⅝	290.2	4.93	*1¼
	⅜	12.87	1.31	66.0	2.26	9⅝	304.5	4.86	0
7″ @ 9.8#	10x¼	8.20	1.10	65.0	2.81	5⅝	87.1	3.26	4⅜
	5/16	8.83	1.37	67.6	2.75	5⅝	92.4	3.23	4⅛
	12x¼	8.70	1.24	68.1	2.80	†7⅝	146.3	4.10	3½
	5/16	9.45	1.45	72.6	2.77	7⅝	155.3	4.06	3⅛
	14x5/16	10.08	1.59	75.4	2.74	9⅝	235.2	4.85	*1½
	⅜	10.95	1.77	79.4	2.69	9⅝	249.6	4.76	0
7″ @ 12.25#	10x¼	9.66	.94	72.4	2.74	5⅜	103.1	3.28	4¼
	5/16	10.29	1.11	77.5	2.74	5⅜	108.4	3.26	3⅝
	12x¼	10.16	1.07	75.9	2.73	†7⅜	173.3	4.14	3½
	5/16	10.91	1.26	81.1	2.72	7⅝	182.3	4.09	3¼
	14x5/16	11.54	1.39	84.6	2.71	9⅜	278.1	4.91	*1½
	⅜	12.41	1.56	89.5	2.68	9⅜	292.4	4.85	0
7″ @ 14.75#	10x5/16	11.77	.97	85.1	2.66	5⅜	118.5	3.19	4
	⅜	12.39	1.11	90.0	2.69	5⅜	123.7	3.17	4
	12x5/16	12.39	1.11	89.2	2.69	7⅜	201.7	4.04	3¼
	⅜	13.14	1.26	94.7	2.68	7⅜	210.7	4.01	3
	14x5/16	13.02	1.24	92.9	2.67	9⅜	309.7	4.87	1⅞
	⅜	13.89	1.40	98.5	2.66	9⅜	324.0	4.83	1⅛
8″ @ 11.5#	12x¼	9.72	1.27	99.9	3.20	7⅜	161.1	4.07	5
	5/16	10.47	1.49	106.3	3.19	7⅜	170.1	4.03	4¾
	14x5/16	11.10	1.64	110.6	3.17	9⅜	260.7	4.87	3½
	⅜	11.97	1.84	116.3	3.13	9⅜	275.0	4.80	2⅞
	16x⅜	12.72	1.98	120.1	3.07	11⅜	394.8	5.56	*1¼
	7/16	13.72	2.15	125.9	3.03	11⅜	416.1	5.51	0
8″ @ 13.75#	12x¼	11.04	1.12	108.7	3.14	7⅛	175.5	3.97	4¾
	5/16	11.79	1.32	116.0	3.14	7⅛	184.5	3.96	4¾
	14x5/16	12.42	1.47	120.6	3.11	9⅛	285.3	4.79	3⅝
	⅜	13.29	1.65	127.6	3.10	9⅛	299.6	4.75	3¼
	16x⅜	14.04	1.79	132.0	3.07	11⅛	432.1	5.55	0
	7/16	15.04	1.96	138.6	3.04	11⅛	453.4	5.50	0
8″ @ 18.75#	12x5/16	14.73	1.06	135.8	3.03	6⅞	225.6	3.92	4½
	⅜	15.48	1.22	143.4	3.04	6⅞	234.6	3.89	4½
	14x⅜	16.23	1.35	150.0	3.03	8⅞	365.4	4.75	3½
	7/16	17.11	1.51	157.6	3.03	8⅞	379.6	4.71	3¼
	16x⅜	16.98	1.48	155.6	3.03	10⅞	528.6	5.58	1¾
	7/16	17.98	1.64	163.8	3.02	10⅞	549.9	5.52	⅞
9″ @ 13.4#	12x¼	10.78	1.30	140.4	3.61	7⅛	174.9	4.04	6
	5/16	11.53	1.51	149.8	3.60	7⅛	183.9	3.99	6
	14x5/16	12.16	1.68	155.4	3.58	9⅛	283.0	4.82	5¼
	⅜	13.03	1.89	163.6	3.54	9⅛	297.3	4.78	5
	16x⅜	13.78	2.04	169.3	3.51	11⅛	427.8	5.60	3⅛
	7/16	14.78	2.24	177.2	3.47	11⅛	449.1	5.52	2¼

[	SIZE COVER PLATE	AREA	e	Axis 1-1		Axis 2-2			b to b where $I_2 = I_1$
				I_1	r_1	b to b = Pl − 2[s − ⅛″			
						b to b	I_2	r_2	
9″ @ 15.0#	12x¼	11.78	1.17	150.9	3.59	6⅞	182.2	3.95	6
	5/16	12.53	1.39	158.6	3.56	6⅞	191.2	3.91	5⅞
	14x5/16	13.16	1.55	164.9	3.55	8⅞	297.2	4.76	5¼
	⅜	14.03	1.75	174.0	3.52	8⅞	311.5	4.72	5
	16x⅜	14.78	1.90	180.1	3.50	10⅞	450.8	5.53	3½
	7/16	15.78	2.09	188.5	3.47	10⅞	472.1	5.48	2⅞
9″ @ 20.0#	12x5/16	15.47	1.13	182.9	3.44	6⅝	228.1	3.83	5½
	⅜	16.22	1.30	192.8	3.44	6⅝	237.1	3.82	5⅝
	14x⅜	16.97	1.45	201.1	3.49	8⅝	372.0	4.69	5
	7/16	17.85	1.62	211.0	3.45	8⅝	386.2	4.65	4⅞
	16x7/16	18.72	1.77	218.6	3.42	10⅝	562.1	5.38	3½
	½	19.72	1.93	228.4	3.40	10⅝	583.5	5.34	3
10″ @ 15.3#	14x5/16	13.32	1.69	212.4	3.97	8⅝	295.2	4.71	6½
	⅜	14.19	1.92	223.0	3.97	8⅝	309.4	4.67	6½
	16x⅜	14.94	2.08	230.8	3.93	10⅝	449.1	5.39	5⅜
	7/16	15.94	2.29	241.1	3.89	10⅝	470.4	5.35	5
	18x7/16	16.82	2.45	247.7	3.83	12⅝	649.0	6.20	2⅜
	½	17.94	2.63	258.0	3.79	12⅝	679.4	6.15	⅞
10″ @ 20.0#	14x5/16	16.10	1.40	242.1	3.88	8⅜	347.1	4.64	6¼
	⅜	16.97	1.61	254.5	3.88	8⅜	361.4	4.63	6¼
	16x⅜	17.72	1.76	263.8	3.85	10⅜	527.9	5.46	5½
	7/16	18.72	1.95	276.7	3.84	10⅜	549.2	5.41	5¼
	18x7/16	19.60	2.10	285.4	3.82	12⅜	760.1	6.24	3½
	½	20.72	2.28	297.5	3.79	12⅜	790.5	6.17	2⅞
10″ @ 25.0#	14x5/16	19.04	1.19	271.1	3.78	8⅛	399.4	4.58	6
	⅜	19.91	1.37	285.5	3.79	8⅛	413.7	4.57	6
	16x⅜	20.66	1.51	296.0	3.79	10⅛	607.8	5.42	5⅜
	7/16	21.66	1.69	310.4	3.79	10⅛	629.1	5.38	5¼
	18x7/16	22.54	1.83	320.8	3.77	12⅛	873.6	6.22	4
	½	23.66	2.00	335.0	3.77	12⅛	904.0	6.19	3⅝
10″ @ 30.0#	14x⅜	22.85	1.19	315.1	3.72	7⅞	464.6	4.51	5¾
	7/16	23.73	1.34	330.5	3.73	7⅞	478.8	4.49	5⅞
	16x7/16	24.60	1.48	343.0	3.73	9⅞	707.3	5.35	5¼
	½	25.60	1.64	357.8	3.73	9⅞	728.7	5.32	5
	18x½	26.60	1.78	370.0	3.72	11⅞	1015.3	6.16	3⅞
	9/16	27.73	1.92	386.4	3.73	11⅞	1045.7	6.14	3⅝
12″ @ 20.7#	16x⅜	18.06	2.06	409.5	4.76	9⅞	519.4	5.36	8⅛
	7/16	19.06	2.29	427.2	4.73	9⅞	540.7	5.34	8
	18x⅜	18.81	2.22	422.2	4.73	†11⅞	721.8	6.20	7⅜
	7/16	19.94	2.46	444.4	4.72	11⅞	752.1	6.15	7¼
	20x7/16	20.81	2.62	452.0	4.74	13⅞	1003.4	6.93	5¾
	½	22.06	2.83	470.5	4.62	13⅞	1045.0	6.89	5⅛
12″ @ 25.0#	16x⅜	20.64	1.80	450.1	4.66	9⅞	599.4	5.39	7⅞
	7/16	21.64	2.01	470.5	4.66	9⅞	620.7	5.35	7⅞
	18x⅜	21.39	1.95	464.4	4.66	†11⅞	832.9	6.19	7¼
	7/16	22.52	2.18	485.0	4.64	11⅞	863.2	6.19	7⅛
	20x7/16	23.39	2.32	499.8	4.64	13⅞	1150.8	7.02	6
	½	24.64	2.54	518.9	4.58	13⅞	1192.4	6.95	5⅝
12″ @ 30.0#	16x⅜	23.58	1.58	493.6	4.56	9⅝	668.3	5.31	7⅝
	7/16	24.58	1.77	516.3	4.56	9⅝	689.6	5.29	7⅝
	18x⅜	24.33	1.72	509.1	4.57	†11⅝	933.2	6.20	7⅛
	7/16	25.46	1.93	532.6	4.58	11⅝	963.5	6.17	7
	20x7/16	26.33	2.07	556.0	4.60	13⅝	1288.3	7.00	6¼
	½	27.58	2.26	572.4	4.56	13⅝	1329.9	6.94	5⅞
15″ @ 33.9#	18x⅜	26.55	1.96	922.4	5.90	†11⅛	997.1	6.11	10½
	7/16	27.68	2.20	961.0	5.90	11⅛	1027.4	6.09	10½
	20x7/16	28.55	2.36	987.8	5.88	13⅛	1377.7	6.94	10⅛
	½	29.80	2.60	1024.6	5.86	13⅛	1419.3	6.90	10
	22x½	30.80	2.76	1051.5	5.90	15⅛	1840.6	7.72	9⅜
	9/16	32.18	2.99	1087.2	5.82	15⅛	1896.0	7.68	9⅛
15″ @ 40.0#	18x⅜	30.15	1.72	1005.7	5.78	10⅞	1106.2	6.06	10⅛
	7/16	31.28	1.94	1044.6	5.78	10⅞	1136.5	6.02	10¼
	20x7/16	32.15	2.10	1072.4	5.78	12⅞	1530.1	6.90	9⅞
	½	33.40	2.32	1113.7	5.78	12⅞	1571.7	6.86	9⅞
	22x½	34.40	2.48	1141.9	5.78	14⅞	2043.4	7.70	9¼
	9/16	35.78	2.69	1183.3	5.77	14⅞	2098.8	7.65	9⅛
15″ @ 50.0#	18x7/16	37.16	1.63	1173.8	5.61	10⅜	1285.6	5.88	9¾
	½	38.28	1.82	1216.8	5.64	10⅜	1316.0	5.86	9¾
	20x½	39.28	1.97	1251.2	5.65	12⅜	1786.3	6.74	9½
	9/16	40.53	2.16	1294.9	5.65	12⅜	1828.0	6.72	9½
	22x9/16	41.66	2.31	1330.2	5.59	14⅜	2390.7	7.57	9
	⅝	43.03	2.50	1373.0	5.64	14⅜	2446.2	7.53	8⅞

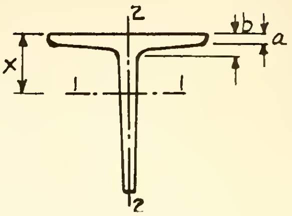
STARRED ANGLES

SIZE OF ANGLES		EQUAL LEG				
						
		AREA SQ. IN.	RAD. GYR. r_3	B TO B ANGLES	AREA SQ. IN.	RAD. GYR. r_1 r_2
2x2	⅛	0.96	.80	5/16	1.92	.83
	3/16	1.42	.79	5/16	2.84	.84
	¼	1.88	.77	5/16	3.76	.85
	5/16	2.30	.76	5/16	4.60	.86
	⅜	2.72	.74	5/16	5.44	.88
2½x2½	3/16	1.80	.97	5/16	3.60	1.04
	¼	2.38	.97	5/16	4.76	1.05
	5/16	2.94	.96	5/16	5.88	1.06
	⅜	3.46	.95	⅜	6.92	1.07
	½	4.50	.94	⅜	9.00	1.08
3x3	3/16	2.18	1.17	5/16	4.36	1.24
	¼	2.88	1.17	5/16	5.76	1.25
	5/16	3.56	1.16	5/16	7.12	1.26
	⅜	4.22	1.16	⅜	8.44	1.27
	7/16	4.86	1.15	⅜	9.72	1.28
	½	5.50	1.13	⅜	11.00	1.29
3½x3½	¼	3.38	1.37	5/16	6.76	1.45
	5/16	4.18	1.36	5/16	8.36	1.47
	⅜	4.96	1.35	⅜	9.92	1.48
	7/16	5.74	1.34	⅜	11.48	1.49
	½	6.50	1.33	⅜	13.00	1.50
4x4	¼	3.88	1.58	5/16	7.76	1.66
	5/16	4.80	1.57	5/16	9.60	1.68
	⅜	5.72	1.56	⅜	11.44	1.68
	7/16	6.62	1.55	⅜	13.24	1.69
	½	7.50	1.53	⅜	15.00	1.70
	⅝	9.22	1.51	7/16	18.44	1.72
	¾	10.88	1.51	7/16	21.76	1.73
5x5	5/16	6.06	1.98	5/16	12.12	2.07
	⅜	7.22	1.98	⅜	14.44	2.08
	7/16	8.36	1.97	⅜	16.72	2.09
	½	9.50	1.95	⅜	19.00	2.10
	⅝	11.72	1.92	7/16	23.44	2.12
	¾	13.88	1.89	7/16	27.76	2.14
	⅞	15.96	1.88	½	31.92	2.15
6x6	5/16	7.32	2.38	5/16	14.64	2.48
	⅜	8.72	2.37	⅜	17.44	2.49
	7/16	10.12	2.36	⅜	20.24	2.50
	½	11.50	2.35	⅜	23.00	2.51
	9/16	12.86	2.34	7/16	25.72	2.52
	⅝	14.22	2.33	7/16	28.44	2.53
	¾	16.88	2.30	½	33.76	2.55
	⅞	19.46	2.28	½	38.92	2.57
	1	22.00	2.26	½	44.00	2.59
8x8	½	15.50	3.17	⅜	31.00	3.32
	9/16	17.36	3.16	⅜	34.72	3.33
	⅝	19.22	3.14	7/16	38.44	3.34
	¾	22.88	3.12	½	45.76	3.36
	⅞	26.46	3.09	½	52.92	3.38
	1	30.00	3.07	½	60.00	3.40
	1⅛	33.46	3.06	½	66.92	3.42

SIZE OF ANGLES		UNEQUAL LEG					
							
		AREA SQ. IN.	RAD. GYR. r_3	B TO B ANGLES	AREA SQ. IN.	RAD. GYR. r_1	RAD. GYR. r_2
2½x2	¼	2.12	.73	5/16	4.24	1.11	.80
	5/16	2.62	.75	5/16	5.24	1.11	.81
	⅜	3.10	.78	5/16	6.20	1.13	.81
3x2½	¼	2.62	1.00	5/16	5.24	1.31	1.00
	5/16	3.24	1.00	5/16	6.48	1.32	1.01
	⅜	3.84	1.00	5/16	7.68	1.33	1.02
3½x2½	¼	2.88	1.10	5/16	5.76	1.58	.96
	5/16	3.56	1.09	5/16	7.12	1.59	.97
	⅜	4.22	1.09	5/16	8.44	1.60	.98
3½x3	¼	3.12	1.22	5/16	6.24	1.52	1.20
	5/16	3.86	1.21	5/16	7.72	1.52	1.22
	⅜	4.60	1.20	5/16	9.20	1.53	1.23
4x3	¼	3.38	1.23	5/16	6.76	1.77	1.16
	5/16	4.18	1.22	5/16	8.36	1.79	1.17
	⅜	4.96	1.21	⅜	9.92	1.80	1.18
	7/16	5.74	1.20	7/16	11.48	1.81	1.19
	½	6.50	1.19	7/16	13.00	1.82	1.20
4x3½	¼	3.62	1.42	5/16	7.24	1.72	1.41
	5/16	4.50	1.42	5/16	9.00	1.73	1.42
	⅜	5.34	1.42	⅜	10.68	1.74	1.42
	7/16	6.18	1.40	7/16	12.36	1.74	1.42
	½	7.00	1.39	7/16	14.00	1.74	1.42
5x3	¼	3.88	1.14	5/16	7.76	2.32	1.07
	5/16	4.80	1.15	5/16	9.60	2.33	1.10
	⅜	5.72	1.16	⅜	11.44	2.34	1.10
	7/16	6.62	1.16	7/16	13.29	2.35	1.11
	½	7.50	1.16	7/16	15.00	2.36	1.11
5x3½	¼	4.12	1.37	5/16	8.24	2.24	1.31
	5/16	5.12	1.37	5/16	10.24	2.26	1.33
	⅜	6.10	1.37	⅜	12.20	2.27	1.34
	7/16	7.06	1.36	7/16	14.12	2.28	1.35
	½	8.00	1.35	7/16	16.00	2.29	1.36
6x4	⅜	7.22	1.56	⅜	14.44	2.74	1.50
	7/16	8.36	1.56	⅜	16.72	2.75	1.50
	½	9.50	1.56	7/16	19.00	2.76	1.51
	9/16	10.62	1.55	7/16	21.24	2.77	1.52
	⅝	11.72	1.55	½	23.44	2.78	1.52
	¾	13.88	1.55	½	27.76	2.80	1.56
7x4	⅜	7.98	1.47	⅜	15.96	3.28	1.42
	7/16	9.26	1.49	⅜	18.52	3.28	1.43
	½	10.50	1.51	7/16	21.00	3.31	1.44
	9/16	11.76	1.51	7/16	23.52	3.31	1.45
	⅝	12.98	1.52	½	25.96	3.32	1.45
	¾	15.38	1.53	½	30.76	3.36	1.49
8x4	7/16	10.12	1.43	⅜	20.24	3.84	1.36
	½	11.50	1.45	7/16	23.00	3.86	1.38
	9/16	12.86	1.45	7/16	25.72	3.87	1.38
	⅝	14.22	1.47	½	28.44	3.88	1.40
	¾	16.88	1.47	½	33.76	3.90	1.42
	⅞	19.46	1.47	½	38.92	3.93	1.44
8x6	7/16	11.86	2.39	⅜	23.72	3.56	2.32
	½	13.50	2.39	7/16	27.00	3.56	2.32
	9/16	15.12	2.38	7/16	30.24	3.57	2.33
	⅝	16.72	2.38	½	33.44	3.58	2.33
	¾	19.88	2.36	½	39.76	3.60	2.35
	⅞	22.96	2.35	½	45.92	3.62	2.37
9x4	½	12.50	1.39	7/16	25.00	4.40	1.32
	9/16	14.00	1.42	½	28.00	4.42	1.33
	⅝	15.46	1.42	½	30.92	4.44	1.34
	¾	18.38	1.43	½	36.76	4.46	1.37
	⅞	21.22	1.43	½	42.44	4.48	1.39
	1	24.00	1.45	⅝	48.00	4.50	1.41

TEES

PROPERTIES AND DIMENSIONS

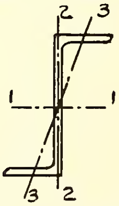


Where 2 dimensions are shown—1st is for Flange, 2nd for Stem.

	Dimensions					WEIGHT PER FOOT	AREA	Axis 1-1				Axis 2-2		
	FLANGE	STEM	THICK a	THICK b	RADIUS FILLET			I	S	r	x	I	S	r
EQUAL	2	2	¼	5/16	¼	3.62	1.05	0.37	0.26	0.59	0.59	0.18	0.18	0.42
	2	2	5/16	⅜	¼	4.4	1.26	0.44	0.31	0.59	0.61	0.23	0.23	0.43
	2¼	2¼	¼	5/16	¼	4.1	1.19	0.52	0.32	0.66	0.65	0.25	0.22	0.46
	2½	2½	5/16	⅜	¼	5.5	1.60	0.88	0.50	0.74	0.74	0.44	0.35	0.52
	2½	2½	⅜	7/16	¼	6.4	1.87	1.0	0.59	0.74	0.76	0.52	0.42	0.53
	3	3	5/16	⅜	5/16	6.7	1.95	1.6	0.74	0.90	0.86	0.75	0.50	0.62
	3	3	⅜	7/16	5/16	7.8	2.27	1.8	0.86	0.90	0.88	0.90	0.60	0.63
	4	4	½	9/16	½	13.5	3.97	5.7	2.0	1.20	1.18	2.8	1.4	0.84
UNEQUAL	3	2½	5/16	⅜	5/16	6.1	1.77	0.94	0.52	0.73	0.68	0.75	0.50	0.65
	4	2½	⅜	7/16	⅜	8.5	2.48	1.2	0.62	0.69	0.62	2.1	1.0	0.92
	4	3	⅜	7/16	⅜	9.2	2.68	2.0	0.90	0.86	0.78	2.1	1.1	0.89
	4	4½	⅜	7/16	½	11.2	3.29	6.3	2.0	1.39	1.31	2.1	1.1	0.80
	5	3	⅜-13/32	7/16-⅝	⅜	11.5	3.37	2.4	1.1	0.84	0.76	3.9	1.6	1.10
	5	3⅛	½-13/32	9/16-⅝	⅜	13.6	4.00	2.7	1.1	0.82	0.76	5.2	2.1	1.14

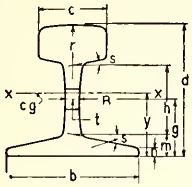
ZEES

PROPERTIES AND DIMENSIONS

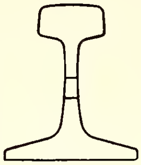


NOM. DEPTH	Dimensions			WEIGHT PER FOOT	AREA	Axis 1-1			Axis 2-2			Axis 3-3
	DEPTH	FLANGE WIDTH	THICKNESS			I	S	r	I	S	r	r
3″	3	2 11/16	¼	6.7	1.97	2.9	1.9	1.21	2.8	1.1	1.19	0.55
	3	2 11/16	⅜	9.8	2.86	3.9	2.6	1.16	3.9	1.6	1.17	0.54
	3	2 11/16	½	12.6	3.69	4.6	3.1	1.12	4.9	2.0	1.15	0.53
4″	4	3 1/16	¼	8.2	2.41	6.3	3.1	1.62	4.2	1.4	1.33	0.67
	4 1/16	3⅛	5/16	10.3	3.03	7.9	3.9	1.62	5.5	1.8	1.34	0.68
	4⅛	3 3/16	⅜	12.5	3.66	9.6	4.7	1.62	6.8	2.3	1.36	0.69
	4 1/16	3⅛	½	15.9	4.66	11.2	5.5	1.55	8.0	2.8	1.31	0.67
5″	5	3¼	5/16	11.6	3.40	13.4	5.3	1.98	6.2	2.0	1.35	0.75
	5 1/16	3 5/16	⅜	14.0	4.10	16.2	6.4	1.99	7.7	2.5	1.37	0.76
	5⅛	3⅜	7/16	16.4	4.81	19.1	7.4	1.99	9.2	2.9	1.38	0.77
	5	3¼	½	17.9	5.25	19.2	7.7	1.91	9.1	3.0	1.31	0.74
6″	6	3½	⅜	15.7	4.59	25.3	8.4	2.35	9.1	2.8	1.41	0.83
	6⅛	3⅝	½	21.1	6.19	34.4	11.2	2.36	12.9	3.8	1.44	0.84

CRANE RAILS

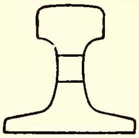


A. S. C. E.

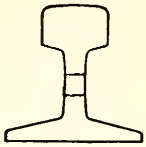


A. R. A.

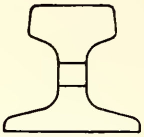
A. R. E. A.



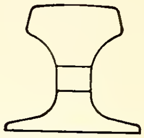
BETHLEHEM 104 LB



CARN.-ILL. 105 LB



BETHLEHEM 171 LB



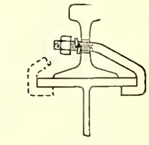
CARN.-ILL. 175 LB

Nomenclature on sketch for A. S. C. E. Rails also applies to other sections

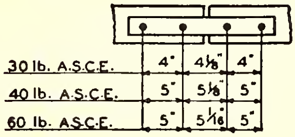
TYPE	WEIGHT POUNDS PER YARD	DEPTH d	WIDTH b	BASE m	BASE n	S (Degrees)	HEAD C (Top)	HEAD C (Bot.)	HEAD RADIUS	WEB t	WEB h	WEB r	WEB GAGE g	AXIS 1-1 GROSS AREA	AXIS 1-1 I	AXIS 1-1 S	AXIS 1-1 y
A. S. C. E.	30	3⅛	3⅛	17/32	11/64	13	1 11/16	1 11/16	12	21/64	1 23/32	12	1 25/64	3.00	4.1	2.5	1.52
	40	3½	3½	⅝	7/32	13	1⅞	1⅞	12	25/64	1 55/64	12	1 71/128	3.94	6.6	3.6	1.68
	60	4¼	4¼	49/64	9/32	13	2⅜	2⅜	12	31/64	2 17/64	12	1 115/128	5.93	14.6	6.6	2.05
	70	4⅝	4⅝	13/16	9/32	13	2 7/16	2 7/16	12	33/64	2 15/32	12	2 3/64	6.81	19.7	8.2	2.22
	80	5	5	⅞	19/64	13	2½	2½	12	35/64	2⅝	12	2 3/16	7.86	26.4	10.1	2.38
	85	5 3/16	5 3/16	57/64	19/64	13	2 9/16	2 9/16	12	9/16	2¾	12	2 17/64	8.33	30.1	11.1	2.47
	90	5⅜	5⅜	59/64	19/64	13	2⅝	2⅝	12	9/16	2 55/64	12	2 45/128	8.83	34.4	12.2	2.55
	100	5¾	5¾	31/32	5/16	13	2¾	2¾	12	9/16	3 5/64	12	2 65/128	9.84	44.0	14.6	2.73
Beth.	104	5	5	1 1/16	½	13	2½	2½	12	1	2 7/16	3½	2 7/16	10.29	29.7	10.6	2.21
C. I.	105	5 3/16	5 3/16	1	13/32	13	2 9/16	2 9/16	12	15/16	2 13/32	12	2 13/64	10.30	34.4	12.4	2.41
Beth.	171	6	6	1¼	⅝	12	4	4 7/16	Flat	1¼	2¾	Vert.	2⅝	16.85	73.6	24.5	3.01
C. I.	175	6	6	1 9/64	½	12	4	4¼	24	1½	3 7/64	Comp.	2 21/32	17.15	71.5	23.7	3.02
A. R. A.—A	90	5⅝	5⅛	1	23/64	14	2 13/32	2 9/16	14	9/16	3 5/32	14	2 37/64	8.82	38.7	12.6	2.54
	100	6	5½	1 1/16	⅜	14	2 19/32	2¾	14	9/16	3⅜	14	2¾	9.84	48.9	15.0	2.75
A. R. A.—B	100	5 41/64	5 9/64	1 5/64	31/64	13	2 9/16	2 21/32	12	9/16	2 55/64	12	2 65/128	9.85	41.3	13.7	2.63
A. R. E. A.	100	6	5⅜	1 1/16	25/64	14	2 9/16	2 11/16	14	9/16	3 9/32	14	2 45/164	9.95	49.0	15.1	2.75
	112	6⅝	5½	1⅛	7/16	14	2 21/32	2 23/32	14	19/32	3 13/16	Comp.	2⅞	11.01	65.5	18.1	3.00
	131	7⅛	6	1 3/16	7/16	14	2 15/16	3	14	21/32	4 3/16	Comp.	3 3/32	12.82	88.5	22.6	3.20

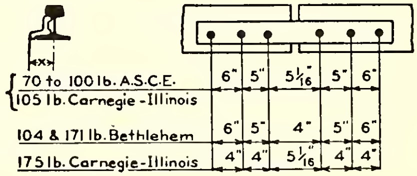
CRANE RAIL SPLICES AND FASTENINGS

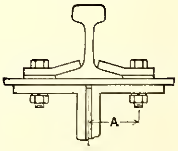
For splice bar contours consult rail manufacturer. Many bars require cutting of bottom flange to clear girder rivet heads. Splice bars are used in pairs. Rails have circular and splice bars have slotted holes to provide for expansion. Bolts should have spring washers under nuts.



Hook Bolts





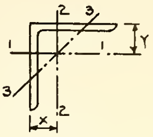


Clamps

Unless otherwise specified, mill will drill for and furnish standard splice bars; for crane up to 25 tons capacity, however, some fabricators use flat bars.

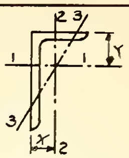
TYPE	WEIGHT POUNDS PER YARD	STANDARD SPLICES CLEARANCE "X"	BOLTS No.	BOLTS DIA.	BOLTS LENGTH	LENGTH SPLICE BAR	WEIGHT 2 BARS	WEIGHT SET BOLTS & WASH.	HOOK BOLTS DIA.	HOOK BOLTS WEIGHT PER PAIR	CLAMPS DIA. BOLTS	CLAMPS MIN. "A"	CLAMPS WT. PLS. & FILLS
A. S. C. E.	30	2	4	⅝	2¾	16⅛	10.5	1.9	⅝	1.8	¾	2 13/16	5
	40	2¼	4	¾	3¼	20	16.1	3.0	¾	2.6	¾	3	5
	60	2¾	4	¾	4	24	32.4	3.3	⅞	3.8	¾	3⅜	6
	70	3	6	¾	4	34	54.6	5.4	⅞	4.0	⅞	3 9/16	8
	80	3¼	6	⅞	4½	34	62.6	7.5	⅞	4.0	⅞	3¾	8
	85	3⅜	6	⅞	4½	34	67.6	7.5	⅞	4.2	⅞	3⅞	8
	90	3½	6	1	4¾	34	72.7	11.4	⅞	4.2	⅞	3 15/16	8
	100	3⅝	6	1	5	34	85.7	11.7			1	4⅛	11
Beth.	104	3½	6	1	5	34	60.6	10.7			1	3⅞	11
C. I.	105	2⅝	6	⅞	4½	34	54.6	7.5			1	3⅞	11
Beth.	171	3	6	1	6	34	76.7	12.2			1	4⅜	12
C. I.	175	4	6	1⅛	6½	26	79.6	18.2			1	4¼	12

ANGLES—EQUAL LEG ELEMENTS



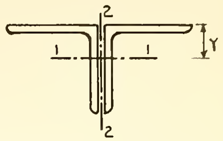
SIZE	THICKNESS	WEIGHT PER FOOT	AREA	Axis 1-1 and Axis 2-2				Axis 3-3
				I	S	r	x	r
2 x 2	⅛	1.65	0.48	0.19	0.13	0.63	0.55	0.40
	3/16	2.44	0.71	0.28	0.19	0.62	0.57	0.40
	¼	3.19	0.94	0.35	0.25	0.61	0.59	0.39
	5/16	3.92	1.15	0.42	0.30	0.60	0.61	0.39
	⅜	4.7	1.36	0.48	0.35	0.59	0.64	0.39
2½ x 2½	3/16	3.07	0.90	0.55	0.30	0.78	0.69	0.49
	¼	4.1	1.19	0.70	0.39	0.77	0.72	0.49
	5/16	5.0	1.47	0.85	0.48	0.76	0.74	0.49
	⅜	5.9	1.73	0.98	0.57	0.75	0.76	0.48
	½	7.7	2.25	1.2	0.73	0.74	0.81	0.47
3 x 3	3/16	3.71	1.09	0.96	0.44	0.94	0.82	0.59
	¼	4.9	1.44	1.2	0.58	0.93	0.84	0.59
	5/16	6.1	1.78	1.5	0.71	0.92	0.87	0.59
	⅜	7.2	2.11	1.8	0.83	0.91	0.89	0.58
	7/16	8.3	2.43	2.0	0.95	0.91	0.91	0.58
	½	9.4	2.75	2.2	1.1	0.90	0.93	0.58
3½ x 3½	¼	5.8	1.69	2.0	0.79	1.09	0.97	0.69
	5/16	7.2	2.09	2.5	0.98	1.08	0.99	0.69
	⅜	8.5	2.48	2.9	1.2	1.07	1.01	0.69
	7/16	9.8	2.87	3.3	1.3	1.07	1.04	0.68
	½	11.1	3.25	3.6	1.5	1.06	1.06	0.68
4 x 4	¼	6.6	1.94	3.0	1.0	1.25	1.09	0.79
	5/16	8.2	2.40	3.7	1.3	1.24	1.12	0.79
	⅜	9.8	2.86	4.4	1.5	1.23	1.14	0.79
	7/16	11.3	3.31	5.0	1.8	1.23	1.16	0.78
	½	12.8	3.75	5.6	2.0	1.22	1.18	0.78
	⅝	15.7	4.61	6.7	2.4	1.20	1.23	0.77
	¾	18.5	5.44	7.7	2.8	1.19	1.27	0.77
5 x 5	5/16	10.3	3.03	7.4	2.0	1.56	1.36	0.99
	⅜	12.3	3.61	8.7	2.4	1.56	1.39	0.99
	7/16	14.3	4.18	10.0	2.8	1.55	1.41	0.98
	½	16.2	4.75	11.3	3.2	1.54	1.43	0.98
	⅝	20.0	5.86	13.6	3.9	1.52	1.48	0.97
	¾	23.6	6.94	15.7	4.5	1.50	1.52	0.97
	⅞	27.2	7.98	17.8	5.2	1.49	1.57	0.96
6 x 6	5/16	12.6	3.66	13.0	3.0	1.89	1.61	1.19
	⅜	14.9	4.36	15.4	3.5	1.88	1.64	1.19
	7/16	17.2	5.06	17.7	4.1	1.87	1.66	1.19
	½	19.6	5.75	19.9	4.6	1.86	1.68	1.18
	9/16	21.9	6.93	22.1	5.1	1.85	1.71	1.18
	⅝	24.2	7.11	24.2	5.7	1.84	1.73	1.17
	¾	28.7	8.44	28.2	6.7	1.83	1.78	1.17
	⅞	33.1	9.73	31.9	7.6	1.81	1.82	1.17
	1	37.4	11.00	35.5	8.6	1.80	1.86	1.16
8 x 8	½	26.4	7.75	48.6	8.4	2.51	2.19	1.58
	9/16	29.6	8.68	54.1	9.3	2.50	2.21	1.58
	⅝	32.7	9.61	59.4	10.3	2.49	2.23	1.58
	¾	38.9	11.44	69.7	12.2	2.47	2.28	1.57
	⅞	45.0	13.23	79.6	14.0	2.45	2.32	1.56
	1	51.0	15.00	89.0	15.8	2.44	2.37	1.56
	1⅛	56.9	16.73	98.0	17.5	2.42	2.41	1.55

ANGLES—UNEQUAL LEG ELEMENTS



SIZE	THICKNESS	WEIGHT PER FOOT	AREA	Axis 1-1 I	Axis 1-1 S	Axis 1-1 r₁	Axis 1-1 y	Axis 2-2 I	Axis 2-2 S	Axis 2-2 r₂	Axis 2-2 x	Axis 3-3 r₃
2x1½	1/8	1.44	0.42	0.17	0.13	0.64	0.62	0.09	0.08	0.45	0.37	0.33
	5/16	2.12	0.62	0.25	0.18	0.63	0.64	0.12	0.11	0.44	0.39	0.32
	1/4	2.77	0.81	0.32	0.24	0.62	0.66	0.15	0.14	0.43	0.41	0.32
2½x1½	3/16	2.44	0.72	0.46	0.28	0.80	0.85	0.13	0.11	0.42	0.35	0.33
	1/4	3.19	0.94	0.59	0.36	0.79	0.88	0.16	0.14	0.41	0.38	0.32
	5/16	3.92	1.15	0.71	0.44	0.79	0.90	0.19	0.17	0.41	0.40	0.32
	3/8	4.70	1.36	0.82	0.52	0.78	0.92	0.22	0.20	0.40	0.42	0.32
2½x2	3/16	2.75	0.81	0.51	0.29	0.79	0.76	0.29	0.20	0.60	0.51	0.43
	1/4	3.62	1.06	0.65	0.38	0.78	0.79	0.37	0.25	0.59	0.54	0.42
	5/16	4.5	1.31	0.79	0.47	0.78	0.81	0.45	0.31	0.58	0.56	0.42
	3/8	5.3	1.55	0.91	0.55	0.77	0.83	0.51	0.36	0.58	0.58	0.42
3x2	3/16	3.07	0.90	0.84	0.41	0.97	0.97	0.31	0.20	0.58	0.47	0.44
	1/4	4.1	1.19	1.1	0.54	0.95	0.99	0.39	0.26	0.57	0.49	0.43
	5/16	5.0	1.47	1.3	0.66	0.95	1.02	0.47	0.32	0.57	0.52	0.43
	3/8	5.9	1.73	1.5	0.78	0.94	1.04	0.54	0.37	0.56	0.54	0.43
	7/16	6.8	2.00	1.7	0.89	0.93	1.06	0.61	0.42	0.55	0.56	0.43
	1/2	7.7	2.25	1.9	1.0	0.92	1.08	0.67	0.47	0.55	0.58	0.43
3x2½	1/4	4.5	1.31	1.2	0.56	0.95	0.91	0.74	0.40	0.75	0.66	0.53
	5/16	5.6	1.62	1.4	0.69	0.94	0.93	0.90	0.49	0.74	0.68	0.53
	3/8	6.6	1.92	1.7	0.81	0.93	0.96	1.0	0.58	0.74	0.71	0.52
	7/16	7.6	2.21	1.9	0.93	0.92	0.98	1.2	0.66	0.73	0.73	0.52
	1/2	8.5	2.50	2.1	1.0	0.91	1.00	1.3	0.74	0.72	0.75	0.52
3½x2½	1/4	4.9	1.44	1.8	0.75	1.12	1.11	0.78	0.41	0.74	0.61	0.54
	5/16	6.1	1.78	2.2	0.93	1.11	1.14	0.94	0.50	0.73	0.64	0.54
	3/8	7.2	2.11	2.6	1.1	1.10	1.16	1.1	0.59	0.72	0.66	0.54
	7/16	8.3	2.43	2.9	1.3	1.09	1.18	1.2	0.68	0.71	0.68	0.54
	1/2	9.4	2.75	3.2	1.4	1.09	1.20	1.4	0.76	0.70	0.70	0.53
3½x3	1/4	5.4	1.56	1.9	0.78	1.11	1.04	1.3	0.58	0.91	0.79	0.63
	5/16	6.6	1.93	2.3	0.96	1.10	1.06	1.6	0.72	0.90	0.81	0.63
	3/8	7.9	2.30	2.7	1.1	1.09	1.08	1.8	0.85	0.90	0.83	0.62
	7/16	9.1	2.65	3.1	1.3	1.08	1.10	2.1	0.98	0.89	0.85	0.62
	1/2	10.2	3.00	3.5	1.5	1.07	1.13	2.3	1.1	0.88	0.88	0.62
4x3	1/4	5.8	1.69	2.8	1.0	1.28	1.24	1.4	0.60	0.89	0.74	0.65
	5/16	7.2	2.09	3.4	1.2	1.27	1.26	1.7	0.74	0.89	0.76	0.65
	3/8	8.5	2.84	4.0	1.5	1.26	1.28	1.9	0.87	0.88	0.78	0.64
	7/16	9.8	2.87	4.5	1.7	1.25	1.30	2.2	1.0	0.87	0.80	0.64
	1/2	11.1	3.25	5.0	1.9	1.25	1.33	2.4	1.1	0.86	0.83	0.64
	5/8	13.6	3.98	6.0	2.3	1.23	1.37	2.9	1.4	0.85	0.87	0.64
4x3½	1/4	6.2	1.81	2.9	1.0	1.27	1.16	2.1	0.81	1.07	0.91	0.73
	5/16	7.7	2.25	3.6	1.3	1.26	1.18	2.6	1.0	1.07	0.93	0.73
	3/8	9.1	2.67	4.2	1.5	1.25	1.21	3.0	1.2	1.06	0.96	0.73
	7/16	10.6	3.09	4.8	1.7	1.24	1.23	3.4	1.3	1.05	0.98	0.72
	1/2	11.9	3.50	5.3	1.9	1.23	1.25	3.8	1.5	1.04	1.00	0.72
	5/8	14.7	4.30	6.4	2.4	1.22	1.29	4.5	1.8	1.03	1.04	0.72
5x3	1/4	6.6	1.94	5.1	1.5	1.62	1.66	1.4	0.61	0.86	0.66	0.66
	5/16	8.2	2.40	6.3	1.9	1.61	1.68	1.8	0.75	0.85	0.68	0.66
	3/8	9.8	2.86	7.4	2.2	1.61	1.70	2.0	0.89	0.84	0.70	0.65
	7/16	11.3	3.31	8.4	2.6	1.60	1.73	2.3	1.0	0.84	0.73	0.65
	1/2	12.8	3.75	9.5	2.9	1.59	1.75	2.6	1.1	0.83	0.75	0.65
5x3½	1/4	7.0	2.06	5.4	1.6	1.61	1.56	2.2	0.83	1.04	0.81	0.76
	5/16	8.7	2.56	6.6	1.9	1.61	1.59	2.7	1.0	1.03	0.84	0.76
	3/8	10.4	3.05	7.8	2.3	1.60	1.61	3.2	1.2	1.02	0.86	0.76
	7/16	12.0	3.53	8.9	2.6	1.59	1.63	3.6	1.4	1.01	0.88	0.76
	1/2	13.6	4.00	10.0	3.0	1.58	1.66	4.0	1.6	1.01	0.91	0.75
	5/8	16.8	4.92	12.0	3.7	1.56	1.70	4.8	1.9	0.99	0.95	0.75
	3/4	19.8	5.81	13.9	4.3	1.55	1.75	5.6	2.2	0.98	1.00	0.75
6x3½	1/4	7.9	2.31	8.9	2.2	1.96	1.99	2.3	0.85	1.01	0.74	0.78
	5/16	9.8	2.87	10.9	2.7	1.95	2.01	2.9	1.0	1.00	0.76	0.77
	3/8	11.7	3.42	12.9	3.2	1.94	2.04	3.3	1.2	0.99	0.79	0.77
	1/2	15.3	4.50	16.6	4.2	1.92	2.08	4.3	1.6	0.97	0.83	0.76
6x4	5/16	10.3	3.03	11.4	2.8	1.94	1.92	4.2	1.4	1.17	0.92	0.88
	3/8	12.3	3.61	13.5	3.3	1.93	1.94	4.9	1.6	1.17	0.94	0.88
	7/16	14.3	4.18	15.5	3.8	1.92	1.96	5.6	1.8	1.16	0.96	0.87
	1/2	16.2	4.75	17.4	4.3	1.91	1.99	6.3	2.1	1.15	0.99	0.87
	9/16	18.1	5.31	19.3	4.8	1.90	2.01	6.9	2.3	1.14	1.01	0.87
	5/8	20.0	5.86	21.1	5.3	1.90	2.03	7.5	2.5	1.13	1.03	0.86
	3/4	23.6	6.94	24.5	6.2	1.88	2.08	8.7	3.0	1.12	1.08	0.86
	7/8	27.2	7.98	27.7	7.2	1.86	2.12	9.8	3.4	1.11	1.12	0.86
7x4	3/8	13.6	3.99	20.6	4.4	2.27	2.37	5.1	1.6	1.13	0.87	0.88
	7/16	15.8	4.63	23.7	5.1	2.26	2.39	5.8	1.9	1.12	0.89	0.88
	1/2	17.9	5.25	26.7	5.8	2.25	2.42	6.5	2.1	1.11	0.92	0.87
	9/16	20.0	5.88	29.6	6.5	2.24	2.44	7.2	2.4	1.11	0.94	0.87
	5/8	22.1	6.49	32.4	7.1	2.24	2.46	7.8	2.6	1.10	0.96	0.86
	3/4	26.2	7.69	37.8	8.4	2.22	2.51	9.1	3.0	1.09	1.01	0.86
	7/8	30.2	8.86	42.9	9.7	2.20	2.55	10.2	3.5	1.07	1.05	0.86
8x4	7/16	17.2	5.06	34.1	6.6	2.60	2.83	6.0	1.9	1.09	0.83	0.87
	1/2	19.6	5.75	38.5	7.5	2.59	2.86	6.7	2.2	1.08	0.86	0.86
	9/16	21.9	6.43	42.8	8.4	2.58	2.88	7.4	2.4	1.07	0.88	0.86
	5/8	24.2	7.11	46.9	9.2	2.56	2.91	8.1	2.6	1.07	0.91	0.86
	3/4	28.7	8.44	54.9	10.9	2.55	2.95	9.4	3.1	1.05	0.95	0.85
	7/8	33.1	9.73	62.4	12.5	2.53	3.00	10.5	3.5	1.04	1.00	0.85
	1	37.4	11.00	69.6	14.1	2.52	3.05	11.6	3.9	1.03	1.05	0.85
8x6	7/16	20.2	5.93	39.2	7.1	2.57	2.45	19.3	4.2	1.80	1.45	1.30
	1/2	23.0	6.75	44.3	8.0	2.56	2.47	21.7	4.8	1.79	1.47	1.30
	9/16	25.7	7.56	49.3	8.9	2.55	2.50	24.0	5.3	1.78	1.50	1.30
	5/8	28.5	8.36	54.1	9.9	2.54	2.52	26.3	5.9	1.77	1.52	1.30
	3/4	33.8	9.94	63.4	11.7	2.53	2.56	30.7	6.9	1.76	1.56	1.29
	7/8	39.1	11.48	72.3	13.4	2.51	2.61	34.9	7.9	1.74	1.61	1.28
	1	44.2	13.00	80.8	15.1	2.49	2.65	38.8	8.9	1.73	1.65	1.28
9x4	1/2	21.3	6.25	53.2	9.3	2.92	3.31	6.9	2.2	1.05	0.81	0.85
	9/16	23.8	7.00	59.1	10.4	2.91	3.33	7.6	2.4	1.04	0.83	0.85
	5/8	26.3	7.73	64.9	11.5	2.90	3.36	8.3	2.6	1.04	0.86	0.85
	3/4	31.3	9.19	76.1	13.6	2.88	3.41	9.6	3.1	1.02	0.91	0.84
	7/8	36.1	10.61	86.8	15.7	2.86	3.45	10.8	3.6	1.01	0.95	0.84
	1	40.8	12.00	97.0	17.6	2.84	3.50	12.0	4.0	1.00	1.00	0.83

2-EQUAL ANGLES
PROPERTIES

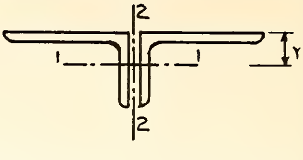


SIZE OF ANGLE		WEIGHT 2 Ls	AREA 2 Ls	Axis 1-1				Radii of Gyration About Axis 2-2						
								DISTANCE BACK TO BACK						
				I	S	r_1	y	0	¼"	5/16"	⅜"	7/16"	½"	⅝"
2 x 2	⅛	3.30	0.96	0.4	0.3	0.63	0.55	0.83	0.92	0.94	0.98	1.00	1.03	1.08
	3/16	4.88	1.42	0.5	0.4	0.62	0.57	0.84	0.93	0.95	0.99	1.01	1.04	1.09
	¼	6.38	1.88	0.7	0.5	0.61	0.59	0.85	0.94	0.96	0.99	1.01	1.04	1.09
	5/16	7.84	2.30	0.8	0.6	0.60	0.61	0.86	0.95	0.97	1.00	1.02	1.05	1.10
	⅜	9.4	2.72	1.0	0.7	0.59	0.64	0.87	0.97	0.99	1.02	1.04	1.07	1.12
2½ x 2½	3/16	6.14	1.80	1.1	0.6	0.78	0.69	1.04	1.13	1.15	1.18	1.20	1.23	1.28
	¼	8.2	2.38	1.4	0.8	0.77	0.72	1.05	1.14	1.16	1.19	1.21	1.24	1.29
	5/16	10.0	2.94	1.7	1.0	0.76	0.74	1.06	1.15	1.17	1.20	1.22	1.25	1.30
	⅜	11.8	3.46	2.0	1.1	0.75	0.76	1.07	1.16	1.18	1.21	1.23	1.26	1.31
	½	15.4	4.50	2.5	1.4	0.74	0.81	1.10	1.19	1.21	1.24	1.26	1.29	1.34
3 x 3	3/16	7.4	2.18	1.9	0.9	0.94	0.82	1.24	1.33	1.35	1.37	1.39	1.42	1.46
	¼	9.8	2.88	2.5	1.2	0.93	0.84	1.25	1.34	1.36	1.38	1.40	1.43	1.48
	5/16	12.2	3.56	3.0	1.4	0.92	0.87	1.26	1.35	1.37	1.40	1.42	1.44	1.49
	⅜	14.4	4.22	3.5	1.7	0.91	0.89	1.28	1.37	1.39	1.41	1.43	1.46	1.51
	7/16	16.6	4.86	4.0	1.9	0.91	0.91	1.28	1.38	1.40	1.42	1.44	1.47	1.52
	½	18.8	5.50	4.4	2.1	0.90	0.93	1.29	1.39	1.41	1.43	1.45	1.48	1.53
3½ x 3½	¼	11.6	3.38	4.0	1.6	1.09	0.97	1.46	1.55	1.57	1.59	1.61	1.64	1.68
	5/16	14.4	4.18	4.9	2.0	1.08	0.99	1.47	1.55	1.58	1.60	1.62	1.65	1.69
	⅜	17.0	4.96	5.7	2.3	1.07	1.01	1.48	1.56	1.59	1.61	1.63	1.66	1.70
	7/16	19.6	5.74	6.5	2.6	1.07	1.04	1.49	1.57	1.60	1.62	1.64	1.67	1.71
	½	22.2	6.50	7.3	3.0	1.06	1.06	1.50	1.59	1.62	1.64	1.66	1.68	1.73
4 x 4	¼	13.2	3.88	6.1	2.1	1.25	1.09	1.66	1.74	1.76	1.79	1.81	1.83	1.88
	5/16	16.4	4.80	7.4	2.6	1.24	1.12	1.67	1.75	1.77	1.80	1.82	1.84	1.89
	⅜	19.6	5.72	8.7	3.0	1.23	1.14	1.68	1.77	1.79	1.81	1.83	1.86	1.91
	7/16	22.6	6.62	9.9	3.5	1.23	1.16	1.69	1.77	1.80	1.82	1.84	1.87	1.92
	½	25.6	7.50	11.1	3.9	1.22	1.18	1.70	1.78	1.81	1.83	1.85	1.88	1.93
	⅝	31.4	9.22	13.3	4.8	1.20	1.23	1.72	1.81	1.83	1.86	1.88	1.91	1.96
	¾	37.0	10.88	15.3	5.6	1.19	1.27	1.74	1.83	1.85	1.88	1.90	1.93	1.98
5 x 5	5/16	20.6	6.06	14.8	4.0	1.56	1.36	2.08	2.16	2.18	2.21	2.23	2.25	2.30
	⅜	24.6	7.22	17.5	4.8	1.56	1.39	2.09	2.17	2.19	2.22	2.24	2.26	2.31
	7/16	28.6	8.36	20.0	5.6	1.55	1.41	2.09	2.18	2.20	2.22	2.25	2.27	2.31
	½	32.4	9.50	22.5	6.3	1.54	1.43	2.10	2.19	2.21	2.23	2.26	2.28	2.32
	⅝	40.0	11.72	27.2	7.7	1.52	1.48	2.12	2.21	2.23	2.26	2.28	2.30	2.35
	¾	47.2	13.88	31.5	9.1	1.51	1.52	2.14	2.23	2.25	2.28	2.30	2.32	2.37
	⅞	54.4	15.96	35.5	10.3	1.49	1.57	2.17	2.26	2.28	2.31	2.33	2.35	2.40
6 x 6	5/16	25.2	7.32	26.0	6.0	1.89	1.61	2.48	2.57	2.59	2.61	2.63	2.65	2.70
	⅜	29.8	8.72	30.8	7.1	1.88	1.64	2.49	2.58	2.60	2.62	2.64	2.66	2.71
	7/16	34.4	10.12	35.4	8.1	1.87	1.66	2.50	2.58	2.61	2.63	2.65	2.67	2.72
	½	39.2	11.50	39.8	9.2	1.86	1.68	2.51	2.59	2.62	2.64	2.66	2.68	2.73
	9/16	43.8	12.86	44.1	10.3	1.85	1.71	2.52	2.60	2.63	2.65	2.67	2.69	2.74
	⅝	48.4	14.22	48.3	11.3	1.84	1.73	2.53	2.62	2.64	2.66	2.68	2.71	2.75
	¾	57.4	16.88	56.3	13.3	1.83	1.78	2.55	2.64	2.66	2.68	2.70	2.73	2.78
	⅞	66.2	19.46	63.8	15.3	1.81	1.82	2.57	2.66	2.68	2.70	2.72	2.75	2.80
	1	74.8	22.00	70.9	17.1	1.80	1.86	2.59	2.68	2.70	2.72	2.74	2.77	2.82
8 x 8	½	52.8	15.50	97.3	16.7	2.50	2.19	3.33	3.41	3.43	3.45	3.47	3.50	3.54
	9/16	59.2	17.36	108.2	18.7	2.50	2.21	3.33	3.41	3.44	3.46	3.48	3.50	3.55
	⅝	65.4	19.22	118.9	20.6	2.49	2.23	3.34	3.42	3.45	3.47	3.49	3.51	3.56
	¾	77.8	22.88	139.5	24.4	2.47	2.28	3.36	3.45	3.47	3.49	3.51	3.54	3.58
	⅞	90.0	26.46	159.2	28.0	2.45	2.32	3.38	3.46	3.48	3.51	3.53	3.55	3.60
	1	102.0	30.00	178.0	31.6	2.44	2.37	3.40	3.49	3.51	3.53	3.55	3.58	3.62
	1⅛	113.8	33.46	195.9	35.1	2.42	2.41	3.42	3.50	3.53	3.55	3.58	3.60	3.64

2-UNEQUAL LEG ANGLES

SHORT LEGS—BACK TO BACK

PROPERTIES



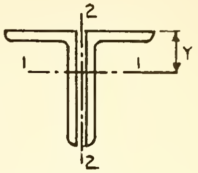
SIZE OF ANGLE		AREA 2 ANGLES	AXIS 1-1 r_1	Radii of Gyration, Axis 2-2						
				DISTANCE BACK TO BACK						
				0	1/4"	5/16"	3/8"	7/16"	1/2"	5/8"
2x1½	1/8	0.84	0.45	0.89	0.98	1.00	1.02	1.05	1.08	1.13
	3/16	1.24	0.44	0.90	0.99	1.01	1.03	1.07	1.09	1.14
	1/4	1.62	0.43	0.91	1.00	1.03	1.05	1.08	1.10	1.16
2½x1½	3/16	1.44	0.42	1.16	1.26	1.28	1.31	1.34	1.36	1.41
	1/4	1.88	0.41	1.17	1.27	1.30	1.32	1.35	1.37	1.42
	5/16	2.30	0.41	1.19	1.28	1.32	1.33	1.37	1.39	1.44
	3/8	2.72	0.40	1.20	1.30	1.33	1.35	1.38	1.41	1.46
2½x2	3/16	1.62	0.60	1.10	1.19	1.21	1.24	1.26	1.29	1.34
	1/4	2.12	0.59	1.11	1.20	1.23	1.25	1.27	1.30	1.35
	5/16	2.62	0.58	1.12	1.21	1.24	1.26	1.28	1.31	1.37
	3/8	3.10	0.58	1.13	1.22	1.25	1.27	1.29	1.32	1.38
3x2	3/16	1.80	0.58	1.37	1.46	1.48	1.51	1.53	1.56	1.61
	1/4	2.38	0.57	1.38	1.47	1.49	1.52	1.54	1.57	1.62
	5/16	2.94	0.57	1.39	1.48	1.50	1.53	1.55	1.58	1.63
	3/8	3.46	0.56	1.40	1.49	1.51	1.54	1.56	1.59	1.64
	7/16	4.00	0.55	1.41	1.51	1.53	1.56	1.58	1.61	1.65
	1/2	4.50	0.55	1.42	1.52	1.54	1.57	1.59	1.62	1.67
3x2½	1/4	2.62	0.75	1.31	1.40	1.42	1.45	1.47	1.50	1.55
	5/16	3.24	0.74	1.32	1.41	1.43	1.46	1.48	1.51	1.56
	3/8	3.84	0.74	1.34	1.43	1.45	1.48	1.50	1.53	1.58
	7/16	4.44	0.73	1.34	1.44	1.47	1.49	1.51	1.54	1.59
	1/2	5.00	0.72	1.35	1.45	1.48	1.50	1.53	1.55	1.60
3½x2½	1/4	2.88	0.74	1.58	1.67	1.69	1.71	1.74	1.76	1.81
	5/16	3.56	0.73	1.60	1.68	1.70	1.73	1.75	1.77	1.82
	3/8	4.22	0.72	1.61	1.69	1.71	1.74	1.76	1.79	1.84
	7/16	4.86	0.71	1.61	1.70	1.72	1.75	1.78	1.80	1.85
	1/2	5.50	0.70	1.62	1.71	1.74	1.76	1.79	1.81	1.86
3½x3	1/4	3.12	0.91	1.52	1.61	1.63	1.65	1.67	1.70	1.75
	5/16	3.86	0.90	1.52	1.61	1.63	1.66	1.68	1.71	1.76
	3/8	4.60	0.90	1.53	1.62	1.64	1.67	1.69	1.72	1.77
	7/16	5.30	0.89	1.54	1.63	1.65	1.68	1.70	1.73	1.78
	1/2	6.00	0.88	1.56	1.64	1.67	1.70	1.72	1.75	1.80
4x3	1/4	3.38	0.90	1.78	1.87	1.89	1.92	1.94	1.96	2.01
	5/16	4.18	0.89	1.79	1.88	1.90	1.93	1.95	1.97	2.02
	3/8	4.96	0.88	1.80	1.89	1.91	1.94	1.96	1.98	2.03
	7/16	5.74	0.87	1.81	1.90	1.92	1.95	1.97	1.99	2.04
	1/2	6.50	0.86	1.82	1.92	1.94	1.96	1.98	2.01	2.06
	5/8	7.96	0.85	1.84	1.94	1.96	1.99	2.01	2.03	2.08
4x3½	1/4	3.62	1.07	1.72	1.80	1.02	1.85	1.87	1.90	1.94
	5/16	4.50	1.07	1.73	1.81	1.83	1.86	1.88	1.91	1.96
	3/8	5.34	1.06	1.74	1.83	1.85	1.88	1.90	1.92	1.97
	7/16	6.18	1.05	1.75	1.84	1.86	1.89	1.92	1.94	1.98
	1/2	7.00	1.04	1.76	1.85	1.87	1.90	1.92	1.94	1.99
	5/8	8.60	1.03	1.77	1.87	1.89	1.91	1.93	1.96	2.01
5x3	1/4	3.88	0.86	2.32	2.41	2.43	2.46	2.48	2.50	2.56
	5/16	4.80	0.85	2.33	2.42	2.44	2.47	2.50	2.52	2.57
	3/8	5.72	0.84	2.34	2.43	2.45	2.48	2.51	2.53	2.58
	7/16	6.62	0.8	2.35	2.44	2.46	2.49	2.52	2.54	2.59
	1/2	7.50	0.83	2.36	2.46	2.48	2.50	2.53	2.55	2.60

SIZE OF ANGLE		AREA 2 ANGLES	AXIS 1-1 r_1	Radius of Gyration, Axis 2-2						
				DISTANCE BACK TO BACK						
				0	1/4"	5/16"	3/8"	1/2"	5/8"	3/4"
5x3½	1/4	4.12	1.04	2.25	2.34	2.36	2.38	2.43	2.48	2.53
	5/16	5.12	1.03	2.26	2.35	2.36	2.38	2.43	2.48	2.53
	3/8	6.10	1.02	2.27	2.36	2.38	2.40	2.45	2.50	2.55
	7/16	7.06	1.01	2.28	2.37	2.39	2.41	2.46	2.51	2.56
	1/2	8.00	1.01	2.29	2.38	2.40	2.43	2.48	2.53	2.58
	5/8	9.84	0.99	2.31	2.40	2.43	2.45	2.50	2.55	2.60
	3/4	11.62	0.98	2.34	2.43	2.45	2.48	2.53	2.58	2.63
6x3½	1/4	4.62	1.01	2.79	2.88	2.91	2.94	2.98	3.02	3.07
	5/16	5.74	1.00	2.80	2.89	2.91	2.94	2.99	3.03	3.08
	3/8	6.84	0.99	2.81	2.90	2.92	2.95	3.00	3.05	3.09
	1/2	9.00	0.97	2.83	2.92	2.95	2.97	3.02	3.07	3.12
6x4	5/16	6.06	1.17	2.73	2.82	2.84	2.86	2.91	2.96	3.00
	3/8	7.22	1.17	2.74	2.83	2.85	2.87	2.92	2.97	3.02
	7/16	8.36	1.16	2.75	2.84	2.86	2.88	2.93	2.98	3.03
	1/2	9.50	1.15	2.76	2.85	2.87	2.90	2.95	2.99	3.04
	9/16	10.62	1.14	2.77	2.86	2.88	2.91	2.96	3.00	3.05
	5/8	11.72	1.13	2.78	2.87	2.89	2.92	2.97	3.01	3.06
	3/4	13.88	1.12	2.80	2.90	2.92	2.95	2.99	3.04	3.09
	7/8	15.96	1.11	2.82	2.92	2.94	2.97	3.02	3.06	3.11
7x4	3/8	7.98	1.13	3.28	3.38	3.40	3.42	3.47	3.52	3.56
	7/16	9.26	1.12	3.29	3.39	3.41	3.43	3.48	3.53	3.57
	1/2	10.50	1.11	3.31	3.40	3.42	3.45	3.49	3.54	3.59
	9/16	11.76	1.11	3.32	3.41	3.43	3.46	3.50	3.55	3.60
	5/8	12.98	1.10	3.32	3.42	3.44	3.47	3.51	3.56	3.61
	3/4	15.38	1.09	3.35	3.44	3.46	3.49	3.54	3.59	3.64
	7/8	17.72	1.07	3.37	3.46	3.48	3.51	3.56	3.61	3.66
8x4	7/16	10.12	1.09	3.85	3.94	3.96	3.99	4.04	4.07	4.12
	1/2	11.50	1.08	3.86	3.95	3.98	4.00	4.05	4.09	4.14
	9/16	12.86	1.07	3.87	3.96	3.99	4.01	4.06	4.10	4.15
	5/8	14.22	1.07	3.88	3.98	4.00	4.02	4.07	4.12	4.17
	3/4	16.88	1.05	3.90	3.99	4.01	4.04	4.09	4.14	4.19
	7/8	19.46	1.04	3.93	4.02	4.04	4.07	4.12	4.17	4.22
	1	22.00	1.03	3.95	4.05	4.07	4.10	4.15	4.20	4.25
8x6	7/16	11.86	1.80	3.55	3.64	3.66	3.68	3.73	3.77	3.82
	1/2	13.50	1.79	3.56	3.65	3.67	3.69	3.74	3.78	3.83
	9/16	15.12	1.78	3.57	3.66	3.68	3.70	3.75	3.79	3.84
	5/8	16.72	1.77	3.58	3.67	3.69	3.72	3.76	3.81	3.85
	3/4	19.88	1.76	3.60	3.69	3.71	3.73	3.78	3.83	3.87
	7/8	22.96	1.74	3.62	3.71	3.73	3.76	3.81	3.85	3.90
	1	26.00	1.73	3.64	3.73	3.75	3.78	3.82	3.87	3.92
9x4	1/2	12.50	1.05	4.41	4.51	4.53	4.55	4.60	4.65	4.70
	9/16	14.00	1.04	4.42	4.51	4.54	4.56	4.61	4.66	4.71
	5/8	15.46	1.04	4.43	4.53	4.55	4.58	4.63	4.68	4.73
	3/4	18.38	1.02	4.46	4.56	4.58	4.61	4.65	4.70	4.75
	7/8	21.22	1.01	4.48	4.58	4.60	4.63	4.68	4.73	4.78
	1	24.00	1.00	4.51	4.61	4.63	4.66	4.71	4.76	4.80

2-UNEQUAL LEG ANGLES

LONG LEGS—BACK TO BACK

PROPERTIES



SIZE OF ANGLE		AREA 2 ANGLES	AXIS 1-1 r_1	Axis 2-2						
				DISTANCE BACK TO BACK						
				0"	1/4"	5/16"	3/8"	7/16"	1/2"	5/8"
2x1½	1/8	0.84	0.64	0.59	0.68	0.70	0.72	0.75	0.77	0.82
	3/16	1.24	0.63	0.59	0.68	0.71	0.73	0.76	0.78	0.83
	1/4	1.62	0.62	0.60	0.69	0.72	0.74	0.77	0.79	0.84
2½x1½	3/16	1.44	0.80	0.55	0.64	0.66	0.68	0.73	0.74	0.78
	1/4	1.88	0.79	0.56	0.65	0.67	0.69	0.74	0.75	0.79
	5/16	2.30	0.79	0.57	0.67	0.68	0.71	0.75	0.77	0.81
	3/8	2.72	0.78	0.58	0.68	0.70	0.73	0.76	0.78	0.83
2½x2	3/16	1.62	0.79	0.79	0.88	0.90	0.92	0.94	0.96	1.02
	1/4	2.12	0.78	0.80	0.89	0.91	0.94	0.96	0.98	1.04
	5/16	2.62	0.78	0.81	0.91	0.93	0.95	0.97	1.00	1.05
	3/8	3.10	0.77	0.81	0.92	0.94	0.96	0.98	1.01	1.06
3x2	3/16	1.80	0.97	0.75	0.83	0.86	0.88	0.90	0.93	0.98
	1/4	2.38	0.95	0.76	0.84	0.87	0.89	0.91	0.94	0.99
	5/16	2.94	0.95	0.77	0.86	0.88	0.90	0.93	0.96	1.00
	3/8	3.46	0.94	0.78	0.87	0.89	0.92	0.94	0.97	1.02
	7/16	4.00	0.93	0.79	0.88	0.90	0.93	0.96	0.98	1.03
	1/2	4.50	0.92	0.80	0.89	0.92	0.94	0.97	0.99	1.04
3x2½	1/4	2.62	0.95	1.00	1.09	1.11	1.13	1.16	1.18	1.23
	5/16	3.24	0.94	1.01	1.10	1.12	1.14	1.17	1.19	1.24
	3/8	3.84	0.93	1.02	1.11	1.14	1.16	1.18	1.21	1.26
	7/16	4.44	0.92	1.03	1.12	1.15	1.17	1.19	1.22	1.27
	1/2	5.00	0.91	1.04	1.14	1.16	1.18	1.21	1.23	1.28
3½x2½	1/4	2.88	1.12	0.95	1.04	1.06	1.09	1.11	1.13	1.18
	5/16	3.56	1.11	0.96	1.05	1.08	1.10	1.12	1.15	1.20
	3/8	4.22	1.10	0.97	1.07	1.09	1.11	1.14	1.16	1.21
	7/16	4.86	1.09	0.98	1.07	1.10	1.12	1.15	1.17	1.22
	1/2	5.50	1.09	0.99	1.08	1.11	1.13	1.16	1.18	1.23
3½x3	1/4	3.12	1.11	1.20	1.29	1.31	1.34	1.36	1.38	1.43
	5/16	3.86	1.10	1.22	1.30	1.32	1.35	1.37	1.39	1.44
	3/8	4.60	1.09	1.23	1.31	1.33	1.36	1.38	1.40	1.45
	7/16	5.30	1.08	1.23	1.32	1.34	1.37	1.39	1.41	1.46
	1/2	6.00	1.07	1.24	1.33	1.36	1.38	1.41	1.43	1.48
4x3	1/4	3.38	1.28	1.16	1.24	1.27	1.29	1.31	1.34	1.38
	5/16	4.18	1.27	1.17	1.25	1.28	1.30	1.32	1.35	1.39
	3/8	4.96	1.26	1.17	1.26	1.28	1.31	1.33	1.36	1.40
	7/16	5.74	1.25	1.18	1.27	1.29	1.32	1.34	1.36	1.41
	1/2	6.50	1.25	1.20	1.28	1.31	1.33	1.36	1.38	1.43
	5/8	7.96	1.23	1.22	1.31	1.33	1.36	1.38	1.41	1.46
4x3½	1/4	3.62	1.27	1.40	1.49	1.51	1.54	1.56	1.58	1.63
	5/16	4.50	1.26	1.42	1.51	1.53	1.55	1.57	1.59	1.64
	3/8	5.34	1.25	1.43	1.52	1.54	1.56	1.58	1.61	1.66
	7/16	6.18	1.24	1.44	1.53	1.55	1.57	1.59	1.62	1.67
	1/2	7.00	1.23	1.44	1.54	1.56	1.58	1.60	1.63	1.68
	5/8	8.60	1.22	1.45	1.55	1.57	1.60	1.62	1.64	1.70
5x3	1/4	3.88	1.62	1.07	1.15	1.18	1.21	1.22	1.24	1.29
	5/16	4.80	1.61	1.09	1.17	1.20	1.22	1.24	1.26	1.31
	3/8	5.72	1.61	1.09	1.18	1.21	1.23	1.25	1.27	1.32
	7/16	6.62	1.60	1.10	1.20	1.22	1.24	1.27	1.29	1.34
	1/2	7.50	1.59	1.11	1.21	1.23	1.25	1.28	1.30	1.35

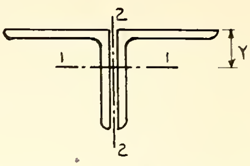
SIZE OF ANGLE		AREA 2 ANGLES	AXIS 1-1 r_1	Axis 2-2						
				DISTANCE BACK TO BACK						
				0"	1/4"	5/16"	3/8"	1/2"	5/8"	3/4"
5x3½	1/4	4.12	1.61	1.31	1.39	1.41	1.43	1.48	1.52	1.56
	5/16	5.12	1.61	1.33	1.41	1.43	1.45	1.50	1.55	1.59
	3/8	6.10	1.60	1.34	1.42	1.44	1.46	1.51	1.56	1.60
	7/16	7.06	1.59	1.35	1.43	1.45	1.47	1.52	1.57	1.62
	1/2	8.00	1.58	1.36	1.44	1.47	1.49	1.54	1.58	1.63
	5/8	9.84	1.56	1.38	1.46	1.49	1.51	1.56	1.60	1.66
	3/4	11.62	1.55	1.40	1.49	1.51	1.54	1.59	1.63	1.69
6x3½	1/4	4.62	1.96	1.24	1.32	1.34	1.36	1.41	1.45	1.49
	5/16	5.74	1.95	1.25	1.33	1.35	1.38	1.42	1.46	1.50
	3/8	6.84	1.94	1.26	1.34	1.36	1.39	1.43	1.48	1.53
	1/2	9.00	1.92	1.27	1.36	1.38	1.40	1.45	1.49	1.55
6x4	5/16	6.06	1.94	1.49	1.57	1.59	1.61	1.66	1.70	1.75
	3/8	7.22	1.93	1.50	1.58	1.60	1.62	1.66	1.71	1.76
	7/16	8.36	1.92	1.50	1.59	1.61	1.63	1.68	1.72	1.77
	1/2	9.50	1.91	1.51	1.60	1.62	1.65	1.69	1.74	1.78
	9/16	10.62	1.90	1.52	1.61	1.63	1.66	1.70	1.75	1.79
	5/8	11.72	1.90	1.53	1.62	1.64	1.66	1.71	1.76	1.81
	3/4	13.88	1.88	1.56	1.64	1.67	1.69	1.74	1.79	1.84
	7/8	15.96	1.86	1.58	1.66	1.69	1.71	1.76	1.81	1.86
7x4	3/8	7.98	2.27	1.43	1.51	1.53	1.55	1.59	1.64	1.68
	7/16	9.26	2.26	1.43	1.51	1.54	1.55	1.60	1.65	1.69
	1/2	10.50	2.25	1.45	1.53	1.55	1.57	1.62	1.66	1.71
	9/16	11.76	2.24	1.45	1.54	1.56	1.58	1.62	1.67	1.72
	5/8	12.98	2.24	1.46	1.55	1.57	1.59	1.64	1.68	1.73
	3/4	15.38	2.22	1.48	1.57	1.59	1.62	1.66	1.71	1.76
	7/8	17.72	2.20	1.50	1.59	1.61	1.64	1.68	1.73	1.78
8x4	7/16	10.12	2.60	1.37	1.45	1.47	1.49	1.53	1.58	1.62
	1/2	11.50	2.59	1.38	1.46	1.48	1.51	1.55	1.60	1.64
	9/16	12.86	2.58	1.39	1.47	1.49	1.53	1.56	1.60	1.65
	5/8	14.22	2.56	1.40	1.49	1.51	1.54	1.58	1.62	1.67
	3/4	16.88	2.55	1.42	1.50	1.53	1.55	1.60	1.64	1.69
	7/8	19.46	2.53	1.44	1.53	1.55	1.58	1.63	1.68	1.72
	1	22.00	2.52	1.47	1.56	1.58	1.61	1.66	1.71	1.76
8x6	7/16	11.86	2.57	2.31	2.39	2.41	2.43	2.47	2.52	2.56
	1/2	13.50	2.56	2.32	2.40	2.42	2.44	2.48	2.53	2.57
	9/16	15.12	2.55	2.33	2.41	2.43	2.46	2.50	2.54	2.59
	5/8	16.72	2.54	2.34	2.42	2.44	2.46	2.51	2.55	2.60
	3/4	19.88	2.53	2.35	2.44	2.46	2.48	2.52	2.57	2.62
	7/8	22.96	2.51	2.37	2.46	2.48	2.50	2.55	2.59	2.64
	1	26.00	2.49	2.39	2.48	2.50	2.52	2.57	2.62	2.66
9x4	1/2	12.50	2.92	1.33	1.41	1.43	1.45	1.49	1.54	1.58
	9/16	14.00	2.91	1.33	1.41	1.45	1.46	1.50	1.55	1.59
	5/8	15.46	2.90	1.35	1.43	1.45	1.47	1.52	1.56	1.61
	3/4	18.38	2.88	1.37	1.45	1.47	1.50	1.55	1.59	1.64
	7/8	21.22	2.86	1.39	1.47	1.49	1.52	1.57	1.62	1.67
	1	24.40	2.84	1.41	1.50	1.53	1.55	1.60	1.65	1.70

A.I.S.C. 1946 Spec.

Heavy line is for
l/r = 120

DOUBLE ANGLE MEMBERS
PROPERTIES AND ALLOWABLE LOADS
TENSION AND COMPRESSION

EQUAL ANGLES—AXIS 1-1



SECTION MODULUS 1-1	RADII OF GYRATION		DISTANCE "X"	WEIGHT 2-Ls	AREA 2-Ls	NET TENSION 2-ANGLES				SIZE OF ANGLES		Allowable Load, Compression, in Kips, For Length in Feet																	
						1-HOLE OUT		2-HOLES OUT																					
	r_1	r_2				¾	⅞	¾	⅞			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	26	28
0.26	0.63	0.97	0.55	3.30	0.96					2x2	⅛	15	14	12	10	9	8	7	6										
0.38	0.62	0.98	0.57	4.88	1.42						3/16	22	20	18	15	13	11	10	8										
0.50	0.61	0.99	0.59	6.38	1.88						¼	29	26	23	19	16	14	12	11										
0.60	0.60	1.00	0.61	7.84	2.30						5/16	35	32	28	23	20	17	15	13										
0.70	0.59	1.02	0.64	9.40	2.72						⅜	41	37	32	27	23	20	17											
0.60	0.78	1.18	0.69	6.14	1.80	30		23		2½ x 2½	3/16	29	27	25	23	20	18	16	14	12	11								
0.78	0.77	1.19	0.72	8.2	2.38	39		30			¼	38	36	33	30	26	23	20	18	16	14								
0.96	0.76	1.20	0.74	10.0	2.94	48		37			5/16	47	44	41	37	33	28	25	22	20	18								
1.14	0.75	1.21	0.76	11.8	3.46	56		43			⅜	55	52	48	43	38	32	29	26	23	20								
1.46	0.74	1.24	0.81	15.4	4.50	72		54			½	71	67	62	56	48	42	37	33	29	26								
0.88	0.94	1.38	0.82	7.42	2.18	37	36	31	28	3x3	3/16	36	34	33	31	28	26	23	20	19	17	14							
1.16	0.93	1.38	0.84	9.8	2.88	49	48	40	38		¼	47	45	43	41	38	34	30	27	25	22	18							
1.42	0.92	1.40	0.87	12.2	3.56	60	59	50	46		5/16	58	56	53	50	46	42	37	33	30	27	23							
1.66	0.91	1.41	0.89	14.4	4.22	71	69	58	54		⅜	70	66	63	59	54	49	43	39	36	32	26							
1.90	0.91	1.42	0.91	16.6	4.86	82	80	67	62		7/16	79	77	72	68	63	56	49	45	41	37	30							
2.2	0.90	1.43	0.93	18.8	5.50	92	90	75	70		½	89	86	82	76	70	63	55	50	46	41	34							
1.58	1.09	1.59	0.97	11.6	3.38	59	58	50	48	3½ x 3½	¼	56	54	52	50	48	45	42	38	35	31	26	22	19					
1.96	1.08	1.60	0.99	14.4	4.18	73	71	62	59		5/16	69	67	65	62	59	55	51	46	42	38	32	27	23					
2.4	1.07	1.61	1.01	17.0	4.96	86	84	72	69		⅜	82	79	76	73	69	65	60	54	50	45	38	32						
2.6	1.07	1.62	1.04	19.6	5.74	100	97	84	80		7/16	94	92	89	85	80	75	69	62	57	51	43	37						
3.0	1.06	1.64	1.06	22.2	6.50	112	110	95	90		½	107	104	100	96	91	85	78	70	64	58	49	41						
2.0	1.25	1.79	1.09	13.2	3.88	69	68	60	58	4x4	¼	64	63	62	60	58	55	52	49	45	41	35	30	26	23				
2.6	1.24	1.80	1.12	16.4	4.80	85	84	74	71		5/16	80	78	76	74	71	68	64	60	55	50	43	37	32	28				
3.0	1.23	1.81	1.14	19.6	5.72	101	99	88	84		⅜	95	93	91	88	84	80	76	71	65	59	51	44	38	33				
3.6	1.23	1.82	1.16	22.6	6.62	117	115	102	97		7/16	109	108	105	102	98	93	88	82	75	68	58	50	44	38				
4.0	1.22	1.83	1.18	25.6	7.50	132	130	115	110		½	124	122	119	115	110	105	99	92	85	77	66	57	49	43				
4.8	1.20	1.86	1.23	31.4	9.22	162	159	140	134		⅝	153	150	146	141	135	128	120	112	102	92	79	68	59	51				
5.6	1.19	1.88	1.27	37.0	10.88	191	188	165	158		¾	179	176	171	166	159	151	141	131	120	108	93	81	69					
4.0	1.56	2.21	1.36	20.6	6.06	110	109	100	96	5x5	5/16	101	100	99	97	94	92	89	86	82	78	69	60	53	47	42	37		
4.8	1.56	2.22	1.39	24.6	7.22	131	129	118	114		⅜	121	120	118	115	113	110	106	102	98	93	82	71	63	56	50	45		
5.6	1.55	2.22	1.41	28.6	8.36	152	150	137	132		7/16	140	138	136	133	130	127	123	118	113	107	95	81	72	65	58	51		
6.4	1.54	2.23	1.43	32.4	9.50	172	170	155	150		½	159	157	155	151	148	144	139	134	128	121	107	92	82	73	65	58		
7.8	1.52	2.26	1.48	40.0	11.72	212	209	190	184		⅝	196	194	191	186	182	177	171	164	156	148	130	112	99	88	79	71		
9.0	1.51	2.28	1.52	47.2	13.88	251	248	225	218		¾	232	230	226	221	215	209	201	193	184	175	153	135	117	105	93	82		
10.4	1.49	2.31	1.57	54.4	15.96	288	284	258	249		⅞	267	262	258	253	246	239	230	221	210	199	173	153	132	119	106	94		
6.0	1.89	2.61	1.61	25.2	7.32	136	134	125	122	6x6	5/16	123	122	121	119	117	115	113	110	107	104	96	88	78	69	63	58	52	48
7.0	1.88	2.62	1.64	29.8	8.72	161	159	148	144		⅜	147	146	144	142	140	137	134	131	127	123	114	104	92	82	75	68	62	56
8.2	1.87	2.63	1.66	34.4	10.12	187	185	172	167		7/16	170	169	167	165	162	159	156	152	148	143	132	120	106	95	87	79	71	65
9.2	1.86	2.64	1.68	39.2	11.50	212	210	195	190		½	193	192	190	187	184	181	175	172	167	162	150	136	120	108	97	89	81	73
10.2	1.85	2.65	1.71	43.8	12.86	238	235	218	212		9/16	216	214	212	209	206	202	197	192	187	181	167	152	134	119	109	99	90	82
11.4	1.84	2.66	1.73	48.4	14.22	262	255	240	230		⅝	239	237	234	231	227	223	218	212	206	200	184	167	147	132	120	108	99	89
13.4	1.83	2.68	1.78	57.4	16.88	311	308	285	278		¾	284	281	278	274	270	264	259	252	244	236	218	197	173	155	140	128	116	105
15.2	1.81	2.70	1.82	66.2	19.46	358	354	328	319		⅞	327	324	320	316	311	304	297	289	280	271	249	225	196	177	160	146	132	120
17.2	1.80	2.72	1.86	74.8	22.00	405	400	370	360		1	370	367	362	357	351	344	335	327	317	306	281	253	220	200	180	163	148	135
16.8	2.50	3.45	2.19	52.8	15.50	292	290	275	270	8x8	½	262	261	259	257	255	253	250	246	243	239	230	221	207	195	180	164	150	140
18.6	2.50	3.46	2.21	59.2	17.36	328	325	309	302		9/16	293	292	290	288	286	283	279	276	272	267	257	245	232	218	201	183	167	156
20.6	2.49	3.47	2.23	65.4	19.22	362	359	340	334		⅝	325	323	321	319	316	313	309	305	301	296	284	271	257	240	222	202	185	172
24.4	2.47	3.49	2.28	77.8	22.88	431	428	405	398		¾	386	384	382	379	376	372	367	363	357	351	338	322	304	284	262	238	219	203
28.0	2.45	3.51	2.32	90.0	26.46	499	494	467	459		⅞	447	445	442	439	435	430	425	419	412	405	389	371	350	326	301	272	250	233
31.6	2.44	3.53	2.37	102.0	30.00	565	560	530	520		1	507	505	501	497	492	487	481	475	468	460	441	420	396	369	340	307	283	263
35.0	2.42	3.55	2.41	113.8	33.46	630	624	590	579		1⅛	564	562	558	554	549	543	536	529	521	512	491	466	440	409	376	339	313	290

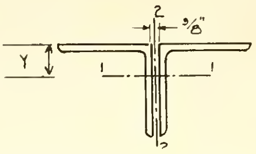
A.I.S.C. 1946 Spec.

Heavy line is for
l/r = 120

DOUBLE ANGLE MEMBERS

PROPERTIES AND ALLOWABLE LOADS
TENSION AND COMPRESSION

EQUAL ANGLES—AXIS 2-2



RADII OF GYRATION		WEIGHT 2-LS	AREA 2-LS	NET TENSION 2-ANGLES				SIZE OF ANGLES		Allowable Load, Compression, in Kips, For Length in Feet																		
				1-HOLE OUT		2-HOLES OUT																						
r_1	r_2			¾	⅞	¾	⅞			5	6	7	8	9	10	11	12	13	14	16	18	20	22	24	26	28	30	32
0.97	0.63	3.30	0.96					2x2	⅛	15	14	13	12	10	9	9	8	7	7	5								
0.98	0.62	4.88	1.42						3/16	21	20	19	17	16	14	13	12	11	10	8								
0.99	0.61	6.38	1.88						¼	28	27	25	23	21	19	17	16	14	13	11								
1.00	0.60	7.84	2.30						5/16	34	33	31	29	26	23	21	19	17	16	14								
1.02	0.59	9.40	2.72						⅜	42	40	37	35	32	28	26	23	21	30	16								
1.18	0.78	6.14	1.80	30		23		2½x2½	3/16	28	27	26	25	23	22	20	18	16	15	13								
1.19	0.77	8.2	2.38	39		30			¼	37	36	35	33	30	29	27	24	21	20	17	15							
1.20	0.76	10.0	2.94	48		37			5/16	46	45	43	41	39	36	33	29	27	25	22	19	16						
1.21	0.75	11.8	3.46	56		43			⅜	55	53	51	48	45	42	39	35	32	30	26	23	20						
1.24	0.74	15.4	4.50	72		54			½	72	69	66	63	60	56	52	47	43	40	45	29	26						
1.38	0.94	7.42	2.18	37	36	31	28	3x3	3/16	35	34	33	32	30	29	27	25	23	21	18	16	14	13					
1.38	0.93	9.8	2.88	49	48	40	38		¼	46	45	44	42	40	38	36	34	31	28	25	22	19	17					
1.40	0.92	12.2	3.56	60	59	50	46		5/16	57	56	54	52	50	48	45	42	39	36	32	28	25	22					
1.41	0.91	14.4	4.22	71	69	58	54		⅜	67	66	64	62	60	57	54	50	47	43	37	33	29	26					
1.42	0.91	16.6	4.86	82	80	67	62		7/16	78	76	74	72	69	66	62	58	54	50	43	38	34	30					
1.43	0.90	18.8	5.50	92	90	75	70		½	88	87	85	82	78	75	71	67	62	57	50	44	39	34					
1.59	1.09	11.6	3.38	59	58	50	48	3½x3½	¼	55	54	53	51	50	48	46	44	42	39	34	30	27	24	21	19			
1.60	1.08	14.4	4.18	73	71	62	59		5/16	68	67	65	63	61	59	57	54	51	48	42	37	33	30	27	24			
1.61	1.07	17.0	4.96	86	84	72	69		⅜	81	80	78	76	74	71	68	65	62	58	50	45	40	36	32	29			
1.62	1.07	19.6	5.74	100	97	84	80		7/16	94	92	90	88	85	82	79	75	72	68	58	52	47	42	37	34			
1.64	1.06	22.2	6.50	112	110	95	90		½	106	104	102	100	97	93	90	86	82	77	67	60	53	48	43	39			
1.79	1.25	13.2	3.88	69	68	60	58	4x4	¼	64	63	62	61	60	58	56	54	52	49	44	39	35	32	29	26	24		
1.80	1.24	16.4	4.80	84	84	74	71		5/16	79	78	77	75	73	71	69	67	64	61	55	48	43	39	36	32	29	27	
1.81	1.23	19.6	5.72	101	99	88	84		⅜	94	93	91	89	87	85	83	80	77	73	66	58	52	47	43	39	35	32	
1.82	1.23	22.6	6.62	117	115	102	97		7/16	108	107	105	103	101	98	95	92	89	85	76	67	61	55	50	45	41	37	
1.83	1.22	25.6	7.50	132	130	115	110		½	123	122	120	117	115	112	109	105	101	97	87	77	69	63	57	52	47	43	
1.86	1.20	31.4	9.22	162	159	140	134		⅝	152	150	148	145	142	138	134	130	125	120	109	96	86	78	71	65	59	54	
1.88	1.19	37.0	10.88	191	188	165	138		¾	179	177	174	171	167	163	159	154	149	143	130	115	103	94	85	77	71	64	
2.21	1.56	20.6	6.06	110	109	100	96	5x5	5/16	101	100	99	97	96	94	92	91	89	86	81	75	69	61	57	52	48		
2.22	1.56	24.6	7.22	131	129	118	114		⅜	120	119	118	116	115	113	111	108	106	103	97	90	82	73	67	62	57		
2.22	1.55	28.6	8.36	152	150	137	132		7/16	139	138	137	135	133	131	128	125	121	119	112	104	95	85	78	72	66		
2.23	1.54	32.4	9.50	172	170	155	150		½	158	157	155	153	151	148	145	142	139	135	127	118	108	97	91	84	76		
2.26	1.52	40.0	11.72	212	209	190	184		⅝	195	193	191	189	186	183	180	176	172	168	158	147	135	122	110	103	95		
2.28	1.51	47.2	13.88	251	248	225	218		¾	231	229	227	224	221	217	213	209	204	199	188	176	161	146	133	122	114		
2.31	1.49	54.4	15.96	288	284	258	249		⅞	267	264	261	258	254	250	246	241	236	230	218	204	188	170	155	143	131		
2.61	1.89	25.2	7.32	136	134	125	122	6x6	5/16	122	121	121	120	118	117	115	114	112	110	105	100	95	88	81	73	69	64	
2.62	1.88	29.8	8.72	161	159	148	144		⅜	146	145	144	143	141	139	137	135	133	131	126	119	113	105	97	88	83	77	
2.63	1.87	34.4	10.12	187	185	172	167		7/16	169	168	167	166	164	161	159	157	153	152	146	138	131	122	113	103	96	89	
2.64	1.86	39.2	11.50	212	210	195	190		½	193	192	190	188	186	184	182	179	176	173	166	158	149	140	129	118	110	102	
2.65	1.85	43.8	12.86	238	235	218	212		9/16	216	214	213	211	209	206	203	200	197	193	186	177	166	157	145	132	123	114	
2.66	1.84	48.4	14.22	262	255	240	230		⅝	239	237	235	233	231	228	225	222	218	214	206	196	186	174	161	147	137	127	
2.68	1.83	57.4	16.88	311	308	285	278		¾	283	281	279	277	274	271	267	263	259	255	245	234	221	208	192	176	164	152	
2.70	1.81	66.2	19.46	358	354	328	319		⅞	326	324	322	319	316	312	308	304	299	294	283	270	256	241	223	205	191	176	
2.72	1.80	74.8	22.00	405	400	370	360		1	369	367	364	361	357	353	349	344	339	333	321	307	291	273	254	234	217	200	
3.45	2.50	52.8	15.50	292	290	275	270	8x8	½	261	260	259	258	256	254	253	251	249	246	241	235	227	221	213	204	194	182	173
3.46	2.50	59.2	17.36	328	325	309	302		9/16	293	292	291	289	287	285	283	281	279	276	270	263	254	247	238	228	218	204	194
3.47	2.49	65.4	19.22	362	359	340	334		⅝	323	323	322	320	318	316	314	311	308	305	299	291	282	274	264	253	241	226	215
3.49	2.47	77.8	22.88	431	428	405	398		¾	385	384	382	381	379	376	374	371	368	364	356	347	336	327	315	303	289	271	258
3.51	2.45	90.0	26.46	499	494	467	459		⅞	446	445	443	440	438	435	432	429	425	421	412	402	390	378	365	350	335	315	301
3.53	2.44	102.0	30.00	565	560	530	520		1	505	504	502	499	496	493	500	486	482	478	468	457	443	431	415	398	382	359	343
3.55	2.42	113.8	33.46	630	624	590	579		1⅛	563	562	560	557	554	550	547	543	539	534	523	510	495	481	465	447	428	402	384

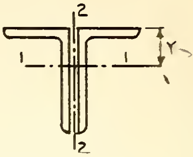
A.I.S.C. 1946 Spec.

Heavy line is for
l/r = 120

DOUBLE ANGLE MEMBERS

PROPERTIES AND ALLOWABLE LOADS
TENSION AND COMPRESSION

UNEQUAL LEGS—SHORT LEGS OUT—AXIS 1-1

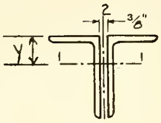


Section Modulus 1-1	Radii of Gyration		Distance "X"	Weight 2-Angles	Area 2-Angles	Net Tension Kips, 2-Angles				Size of Angles		Allowable Load, Compression, in Kips, For Length in Feet																	
	r_1	r_2				1-Hole Out		2-Holes Out				3	4	5	6	7	8	9	10	11	12	13	14	15	16	18	20	22	24
						3/4	7/8	3/4	7/8																				
0.58	0.79	0.92	0.76	5.50	1.62	26				2½x2	3/16	26	25	23	21	19	16	14	12	11	10	9							
0.76	0.78	0.93	0.79	7.24	2.12	34					1/4	34	32	30	27	24	21	19	17	15	13	12							
0.94	0.78	0.95	0.81	9.00	2.62	42					5/16	42	40	37	34	30	26	23	20	18	16	15							
1.08	0.96	0.89	0.99	8.20	2.38	39	38			3x2	1/4	39	38	36	34	32	29	26	23	21	19	17	16						
1.32	0.95	0.90	1.02	10.00	2.94	48	46				5/16	48	46	44	42	39	35	32	28	25	23	21	19						
1.56	0.94	0.92	1.04	11.80	3.46	56	54				3/8	56	54	52	49	45	41	37	33	30	27	25	22						
1.12	0.95	1.13	0.91	9.00	2.62	44	42	35	32	3x2½	1/4	42	41	39	37	35	32	28	25	23	20	19	17	16					
1.38	0.94	1.14	0.93	11.20	3.24	54	52	43	40		5/16	52	51	49	46	43	39	34	31	28	25	23	21	19					
1.62	0.93	1.16	0.96	13.20	3.84	64	62	50	46		3/8	62	60	57	54	50	45	40	36	33	30	27	25	22					
1.50	1.12	1.09	1.11	9.8	2.88	49	47	40	38	3½x2½	1/4	47	46	45	43	41	39	36	33	29	27	25	23	21	20	17			
1.86	1.11	1.10	1.14	12.2	3.56	60	59	50	46		5/16	58	57	55	53	51	48	44	40	36	33	31	28	26	24	21			
2.20	1.10	1.11	1.16	14.4	4.22	71	69	58	54		3/8	70	68	66	63	60	56	51	47	42	39	36	33	30	28	24			
2.60	1.09	1.12	1.18	16.6	4.86	82	80	67	62		7/16	80	78	76	73	69	65	60	54	48	45	42	38	35	32	28			
2.80	1.09	1.13	1.20	18.8	5.50	92	90	75	70		1/2	90	88	85	82	78	73	67	61	54	50	47	43	40	36	31			
1.56	1.11	1.34	1.04	10.8	3.12	54	52	45	42	3½x3	1/4	51	50	49	47	44	42	39	35	32	29	27	25	23	21	18			
1.92	1.10	1.35	1.06	13.2	3.86	66	65	56	52		5/16	64	62	60	58	55	51	48	43	39	36	33	30	28	26	22			
2.20	1.09	1.36	1.08	15.8	4.60	79	77	66	62		3/8	76	74	71	68	65	61	56	51	46	42	39	36	33	30	26			
2.60	1.08	1.37	1.10	18.2	5.30	91	88	76	71		7/16	87	85	82	78	75	70	64	58	52	47	44	41	38	34	29			
3.00	1.07	1.38	1.13	20.4	6.00	102	100	85	80		1/2	99	96	93	89	84	79	72	65	59	54	50	46	42	39				
2.00	1.28	1.29	1.24	11.6	3.38	59	58	50	48	4x3	1/4	56	55	54	52	50	48	46	43	40	37	33	31	29	27	23	21		
2.40	1.27	1.30	1.26	14.4	4.18	73	71	62	59		5/16	69	68	67	65	62	59	56	53	49	45	41	38	36	33	29	25		
3.00	1.26	1.31	1.28	17.0	4.96	86	84	73	69		3/8	82	81	79	76	74	70	67	63	58	53	48	45	42	39	34	30		
3.40	1.25	1.32	1.30	19.6	5.74	100	97	84	80		7/16	95	94	91	89	85	82	77	72	67	61	55	52	48	45	39	34		
3.80	1.25	1.33	1.33	22.2	6.50	112	110	95	90		1/2	108	106	103	100	96	92	87	81	75	69	63	58	54	51	44	38		
2.00	1.27	1.54	1.16	12.4	3.62	64	62	55	52	4x3½	1/4	60	59	57	56	54	52	49	46	42	39	36	33	31	29	25	22		
2.60	1.26	1.55	1.18	15.4	4.50	79	78	68	65		5/16	75	73	71	69	67	64	60	57	53	48	44	41	38	35	31	27		
3.00	1.25	1.56	1.21	18.2	5.34	94	92	80	76		3/8	89	87	85	82	79	76	71	67	62	56	52	48	45	42	36	32		
3.40	1.24	1.57	1.23	21.2	6.18	108	106	93	88		7/16	102	101	98	94	91	87	82	77	71	64	59	56	51	48	41	36		
3.80	1.23	1.58	1.25	23.8	7.00	122	120	105	100		1/2	116	114	111	107	103	98	93	87	80	72	67	62	58	54	46	40		
3.00	1.62	1.21	1.66	13.2	3.88	69	67	60	58	5x3	1/4	65	64	63	61	59	57	56	55	54	51	49	46	43	40	35	31	28	25
3.80	1.61	1.22	1.68	16.4	4.80	85	82	74	71		5/16	80	79	78	77	75	73	71	68	66	63	60	56	52	49	43	39	35	31
4.40	1.61	1.23	1.70	19.6	5.72	101	97	88	84		3/8	96	95	93	92	90	87	85	81	78	75	71	67	62	57	51	46	41	37
5.20	1.60	1.24	1.73	22.6	6.62	117	112	102	97		7/16	111	109	108	106	103	101	97	94	91	86	82	77	72	67	59	53	47	43
5.80	1.59	1.25	1.75	25.6	7.50	132	128	115	110		1/2	125	124	122	120	117	114	111	107	102	97	92	87	81	75	67	59	53	48
3.20	1.61	1.44	1.56	14.0	4.12	73	72	65	63	5x3½	1/4	69	68	67	66	65	63	61	59	57	54	51	48	45	42	37	33	30	28
3.80	1.61	1.45	1.59	17.4	5.12	92	90	81	78		5/16	86	85	84	82	80	78	76	73	70	67	64	60	56	52	46	41	37	33
4.60	1.60	1.46	1.61	20.8	6.10	109	107	96	92		3/8	102	101	100	98	96	93	90	87	84	80	76	71	66	61	55	49	44	39
5.20	1.59	1.47	1.63	24.0	7.06	126	124	111	106		7/16	118	116	115	113	111	108	104	100	97	92	87	81	76	70	63	56	50	45
6.00	1.58	1.49	1.66	27.2	8.00	142	140	125	120		1/2	134	132	130	128	125	122	118	114	109	104	98	92	86	79	71	63	56	51
7.40	1.56	1.51	1.70	33.6	9.84	175	172	153	146		5/8	165	163	160	157	154	149	144	139	133	127	120	112	104	95	86	76	68	61
8.60	1.55	1.54	1.75	39.6	11.62	206	202	180	172		3/4	195	192	189	185	181	176	170	164	157	149	141	131	121	113	101	90	80	72
4.40	1.96	1.37	1.99	15.8	4.62	84	81	75	72	6x3½	1/4	78	77	76	75	74	73	72	70	68	66	64	62	60	57	52	46	42	38
5.40	1.95	1.38	2.01	19.6	5.74	104	101	93	90		5/16	97	96	95	93	92	91	89	87	85	82	80	77	74	70	63	56	51	47
6.40	1.94	1.39	2.04	23.4	6.84	123	119	110	106		3/8	115	114	113	112	110	108	106	104	101	98	95	91	88	84	75	66	61	55
8.40	1.92	1.40	2.08	30.6	9.00	162	157	145	140		1/2	151	150	149	147	145	142	139	136	132	128	124	119	115	109	98	87	79	72
5.6	1.94	1.66	1.92	20.6	6.06	111	109	100	96	6x4	5/16	102	101	100	99	98	96	94	92	89	87	84	81	78	74	67	59	54	49
6.6	1.93	1.67	1.94	24.6	7.22	131	129	118	114		3/8	121	120	119	118	116	114	112	109	106	103	100	96	92	88	79	70	64	58
7.6	1.92	1.68	1.96	28.6	8.36	152	150	137	132		7/16	141	140	138	136	134	132	129	126	123	119	115	111	107	102	91	81	73	67
8.6	1.91	1.69	1.99	32.4	9.50	173	170	155	150		1/2	160	159	157	155	153	150	147	143	139	135	131	126	121	115	103	91	83	76
9.6	1.90	1.70	2.01	36.2	10.62	193	190	173	168		9/16	179	177	175	173	171	168	164	160	156	151	146	141	134	128	114	102	93	84
10.6	1.90	1.71	2.03	40.0	11.72	212	209	190	184		5/8	197	196	194	191	188	185	181	177	172	167	161	155	148	141	126	112	102	93
12.4	1.88	1.74	2.08	47.2	13.88	251	248	225	218		3/4	234	232	229	226	223	218	214	209	203	196	190	182	175	166	147	131	119	108
14.4	1.86	1.76	2.12	54.4	15.96	288	284	258	249		7/8	268	266	263	260	256	251	245	239	232	225	217	208	199	189	167	149	136	123
8.8	2.27	1.59	2.37	27.2	7.98	146	144	133	129	7x4	3/8	135	134	133	132	130	128	127	125	123	120	117	114	111	108	100	92	83	76
10.2	2.26	1.60	2.39	31.6	9.26	170	168	155	150		7/16	156	155	154	153	151	149	147	144	142	139	136	132	129	125	116	107	96	87
11.6	2.25	1.62	2.42	35.8	10.50	193	190	175	170		1/2	177	176	175	173	171	169	167	164	161	158	154	150	146	141	132	112	108	99
13.0	2.24	1.63	2.44	40.0	11.76	216	213	196	190		9/16	199	197	196	194	192	189	187	183	180	176	172	167	163	157	146	134	120	110
14.2	2.24	1.64	2.46	44.2	12.98	238	234	216	209		5/8	219	218	216	214	212	209	206	202	199	194	190	185	180	174	162	148	133	122
16.8	2.22	1.66	2.51	52.4	15.38	281	278	255	248		3/4	259	258	256	254	251	248	244	240	235	230	225	219	212	206	191	174	156	143
19.4	2.20	1.68	2.55	60.4	17.72	324	319	293	284		7/8	299	297	295	292	289	285	281	276	270	264	258	251	244	236	218	199	177	163
13.2	2.60	1.53	2.83	34.4	10.12	187	185	172	167	8x4	7/16	171	170	169	168	167	165	164	162	159	157	154	152	149	145	138	130	121	112
15.0	2.59	1.55	2.86	39.2	11.50	212	210	195	190		1/2	194	193	192	191	190	188	186	184	181	178	175	172	169	165	157	148	138	127
16.8	2.58	1.57	2.88	43.8	12.86	237	235	218	212		9/16	217	216	215	214	212	210	208	205	202	199	196	192	188	184	175	165	153	141
18.4	2.56	1.58	2.91	48.4	14.22	262	259	240	234		5/8	240	239	238	236	234	232	229	227	224	220	216	212	208	203	193	182	169	155
21.8	2.55	1.60	2.95	57.4	16.88	311	307	285	278		3/4	285	284	283	281	278	275	272	269	265	261	256	251	246	241	228	214	199	183
25.0	2.53	1.63	3.00	66.2	19.46	358	354	328	319		7/8	329	327	325	323	321	317	313	310	305	300	295	289	283	276	262	246	228	208
28.2	2.52	1.66	3.05	74.8	22.00	405	400	370	360		1	372	370	368	365	362	358	354	350	345	339	333	327	320	312	296	277	257	234
14.2	2.57	2.48	2.45	40.4	11.86	222	220	207	202	8x6	7/16	201	200	198	197	196	194	191	189	186	184	181	177	173	169	161	151	141	129
16.0	2.56	2.48	2.47	46.0	13.50	252	250	235	230		1/2	228	227	226	224	222	220	218	215	212	209	205	201	197	193	183	172	160	147
17.8	2.55	2.50	2.50	51.4	15.12	283	280	263	258		9/16	256	254	253	251	249	247	244	241	237	234	229	225	220	215	204	192	178	163
19.8	2.54	2.51	2.52	57.0	16.72	312	309	290	284		5/8	283	281	279	277	275	273	270	266	262	258	254	249	244	238	226	212	197	180
23.4	2.53	2.52	2.56	67.6	19.88	371	368	345	338		3/4	336	334	332	330	327	324	320	316	312	307	301	295	289	282	268	251	233	214
26.8	2.51	2.55	2.61	78.2	22.96	428	424	398	389		7/8	388	386	384	381	378	374	370	365	360	354	347	340	333	325	308	288	267	244
30.2	2.49	2.57	2.65	88.4	26.00	485	480	450	440		1	440	437	434	431	428	424	418	413	406	400	392	385	376	367	347	325	300	273
18.6	2.92	1.45	3.31	42.6	12.50	232	230	215	212	9x4	1/2	212	211	210	209	208	207	204	202	200	198	195	192	189	186	179	172	163	153
20.8	2.91	1.46	3.33	47.6	14.00	261	258	242	239		9/16	237	236	235	234	232	230	228	227	224	221	218	215	212	208	201	192	182	172
23.0	2.90	1.47	3.36	52.6	15.46	287	284	265	262		5/8	261	260	259	258	257	255	253	250	247	244	241	238	234	230	221	211	201	189
27.2	2.88	1.50	3.41	62.6	18.38	341	337	315	311		3/4	311	310	308	307	305	303	300	297	294	290	286	282	277	273	262	251	237	222
31.4	2.86	1.52	3.45	72.2	21.22	394	389	363	358		7/8	360	359	357	355	352	349	346	342	339	335	330	325	319	314	302	288	273	256
35.2	2.84	1.55	3.50	81.6	24.00	445	440	410	405		1	406	405	403	400	398	395	392	387	383	378	372	367	361	355	341	325	307	289

A.I.S.C. 1946 Spec.

Heavy line is for
$l/r = 120$

DOUBLE ANGLE MEMBERS
PROPERTIES AND ALLOWABLE LOADS
TENSION AND COMPRESSION
UNEQUAL LEGS—SHORT LEGS OUT—AXIS 2-2



Radii of Gyration		Weight 2-Angles	Area 2-Angles	Net Tension 2-Angles				Size of Angles		Allowable Load, Compression, in Kips, For Length in Feet																		
				1-Hole Out		2-Holes Out																						
r_2	r_1			3/4	7/8	3/4	7/8			4	5	6	7	8	9	10	11	12	13	14	16	18	20	22	24	26	28	30
0.92	0.79	5.50	1.62	26				2½x2	3/16	25	24	23	21	19	17	15	14	12	11	10								
0.94	0.78	7.24	2.12	34					1/4	33	32	30	28	25	22	20	18	16	15	14								
0.95	0.78	9.00	2.62	42					5/16	41	39	37	35	32	28	25	23	21	19	17								
0.89	0.96	8.20	2.38	39	38			3x2	1/4	37	35	33	30	27	24	21	19	17	16	14								
0.90	0.95	10.00	2.94	48	46				5/16	46	44	41	38	34	30	27	24	22	20	18								
0.92	0.94	11.80	3.46	56	54				3/8	54	52	49	45	41	36	32	29	26	24	22								
1.13	0.95	9.00	2.62	44	42	35	32	3x2½	1/4	42	41	39	38	36	33	31	27	25	23	21	18	16						
1.14	0.94	11.20	3.24	54	52	43	40		5/16	52	51	49	47	44	41	38	34	31	29	26	23	19						
1.16	0.93	13.20	3.84	64	62	50	46		3/8	62	60	58	56	53	49	45	41	37	34	32	27	24						
1.09	1.12	9.8	2.88	49	47	40	38	3½x2½	1/4	46	45	43	40	38	35	32	29	26	24	22	19	16						
1.10	1.11	12.2	3.56	60	59	50	46		5/16	57	55	53	50	47	43	40	36	33	31	28	24	20						
1.11	1.10	14.4	4.22	71	69	58	54		3/8	68	66	63	60	56	52	48	43	39	36	33	29	24						
1.12	1.09	16.6	4.86	82	80	67	62		7/16	78	76	73	69	65	60	55	50	45	42	38	33	28						
1.13	1.09	18.8	5.50	92	90	75	70		1/2	89	86	83	78	74	69	63	57	52	48	44	38	33						
1.34	1.11	10.8	3.12	54	52	45	42	3½x3	1/4	51	50	49	47	45	43	41	38	36	32	30	26	23	20	18				
1.35	1.10	13.2	3.86	66	65	56	52		5/16	63	62	60	58	56	54	51	48	44	40	37	33	29	25	23				
1.36	1.09	15.8	4.60	79	77	66	62		3/8	75	74	72	70	67	64	61	57	53	49	45	39	34	30	27				
1.37	1.08	18.2	5.30	91	88	76	71		7/16	86	85	83	81	77	74	70	66	61	57	52	45	40	35	31				
1.38	1.07	20.4	6.00	102	100	85	80		1/2	98	96	94	91	88	84	80	75	70	65	59	52	46	40	36				
1.29	1.28	11.6	3.38	59	58	50	48	4x3	1/4	55	54	52	50	48	46	43	40	37	33	31	27	24	21					
1.30	1.27	14.4	4.18	73	71	62	59		5/16	68	67	65	63	60	57	54	50	46	42	39	34	30	26					
1.31	1.26	17.0	4.96	86	84	73	69		3/8	81	79	77	74	71	68	64	60	55	50	47	41	36	31					
1.32	1.25	19.6	5.74	100	97	84	80		7/16	93	92	89	86	82	79	74	70	64	59	54	47	41	36	32				
1.33	1.25	22.2	6.50	112	110	95	90		1/2	106	104	101	98	94	90	85	79	74	67	62	54	47	42	37				
1.54	1.27	12.4	3.62	64	62	55	52	4x3½	1/4	60	59	58	57	55	53	51	48	46	44	41	35	31	28	25	22			
1.55	1.26	15.4	4.50	79	78	68	65		5/16	74	73	72	70	68	66	63	61	58	55	51	44	39	35	31	28			
1.56	1.25	18.2	5.34	94	92	80	76		3/8	88	87	85	83	81	78	75	72	69	65	61	52	47	41	37	33	30		
1.57	1.24	21.2	6.18	108	106	93	88		7/16	102	101	99	97	93	91	87	84	80	76	71	60	54	48	43	39	35		
1.58	1.23	23.8	7.00	122	120	105	100		1/2	116	114	112	109	106	103	99	95	91	86	81	69	62	55	49	44	40		
1.21	1.62	13.2	3.88	69	67	60	58	5x3	1/4	63	61	59	57	54	51	47	44	39	36	34	29	25	22					
1.22	1.61	16.4	4.80	85	82	74	71		5/16	78	76	73	70	67	63	59	54	49	46	42	36	31	27					
1.23	1.61	19.6	5.72	101	97	88	84		3/8	93	91	88	84	80	76	71	65	59	55	50	43	38	33					
1.24	1.60	22.6	6.62	117	112	102	97		7/16	108	105	102	98	94	88	82	77	69	63	59	51	44	38					
1.25	1.59	25.6	7.50	132	128	115	110		1/2	122	119	115	111	106	100	94	87	80	74	67	58	51	44					
1.43	1.61	14.0	4.12	73	72	65	63	5x3½	1/4	68	67	66	65	63	61	59	57	54	52	48	42	37	33					
1.45	1.61	17.4	5.12	92	90	81	78		5/16	84	83	81	79	76	73	70	66	63	58	54	47	41	37	32	29			
1.46	1.60	20.8	6.10	109	107	96	92		3/8	101	99	97	94	91	87	84	80	75	70	65	56	50	44	39	35			
1.47	1.59	24.0	7.06	126	124	111	106		7/16	117	114	112	109	106	101	98	92	88	82	76	66	58	51	45	40			
1.49	1.58	27.2	8.00	142	140	125	120		1/2	132	130	127	124	120	116	111	106	100	93	87	75	66	59	53	47			
1.51	1.56	33.6	9.84	175	172	153	146		5/8	162	159	156	153	148	143	137	131	124	116	108	93	83	74	66	59			
1.54	1.55	39.6	11.62	206	202	180	172		3/4	192	189	185	181	176	170	163	156	148	139	130	112	100	89	79	71			
1.36	1.96	15.8	4.62	84	81	75	72	6x3½	1/4	76	74	72	70	67	64	61	58	53	49	45	39	35	30	27				
1.38	1.95	19.6	5.74	104	101	93	90		5/16	94	92	90	87	84	80	76	72	67	62	57	50	44	38	34				
1.39	1.94	23.4	6.84	123	119	110	106		3/8	112	110	107	104	100	96	91	86	80	74	68	60	53	46	41				
1.40	1.92	30.6	9.00	162	157	145	140		1/2	148	145	141	137	133	127	121	114	107	99	91	79	70	62	54				
1.61	1.94	20.6	6.06	111	109	100	96	6x4	5/16	101	99	97	95	93	91	88	84	81	77	73	64	56	50	45	40	37		
1.62	1.93	24.6	7.22	131	129	118	114		3/8	120	118	116	114	110	108	104	101	95	90	85	74	65	61	54	47	44		
1.63	1.92	28.6	8.36	152	150	137	132		7/16	139	137	134	132	128	125	120	117	110	105	99	86	76	71	63	55	52		
1.65	1.91	32.4	9.50	173	170	155	150		1/2	158	156	153	150	146	143	137	133	126	120	114	99	88	81	73	64	59		
1.66	1.90	36.2	10.62	193	190	173	168		9/16	176	174	171	168	163	160	154	149	141	134	127	110	98	91	82	71	67		
1.66	1.90	40.0	11.72	212	209	190	184		5/8	195	192	189	186	180	177	170	165	156	149	141	123	109	101	91	79	74		
1.69	1.88	47.2	13.88	251	248	225	218		3/4	231	228	224	220	214	211	202	197	187	178	169	149	131	121	110	96	90	78	
1.71	1.86	54.4	15.96	288	284	258	249		7/8	266	263	258	254	247	242	233	228	216	207	197	174	152	142	128	112	105	91	
1.55	2.27	27.2	7.96	146	144	133	129	7x4	3/8	132	130	127	125	121	118	112	109	102	96	90	77	69	62	55	48			
1.55	2.26	31.6	9.24	170	168	155	150		7/16	153	151	148	145	140	137	131	127	119	112	105	89	80	72	64	55			
1.57	2.25	35.8	10.50	193	190	175	170		1/2	174	172	168	165	159	156	149	145	136	128	120	103	93	83	73	66	59		
1.58	2.24	40.0	11.74	216	213	196	190		9/16	195	192	188	185	178	175	167	162	153	144	135	116	103	93	83	75	67		
1.59	2.24	44.2	12.96	238	234	216	209		5/8	215	212	207	204	197	193	185	180	169	160	150	129	115	104	92	83	74		
1.62	2.22	52.4	15.38	281	278	255	248		3/4	255	252	247	242	235	230	221	214	203	192	181	157	140	126	112	103	91		
1.64	2.20	60.4	17.72	324	319	293	284		7/8	294	290	285	280	272	266	255	248	235	223	211	183	162	147	131	119	106		
1.49	2.60	34.4	10.12	187	185	172	167	8x4	7/16	167	164	160	157	152	148	140	133	126	118	109	95	85	74	67	59			
1.51	2.59	39.2	11.50	212	210	195	190		1/2	190	187	183	179	173	168	160	153	145	136	126	109	98	86	77	68			
1.51	2.58	43.8	12.86	237	235	218	212		9/16	213	210	206	201	195	189	182	170	162	152	141	122	108	96	86	77			
1.53	2.57	48.4	14.22	262	259	240	234		5/8	235	232	226	222	214	210	199	190	181	170	158	136	122	108	97	86			
1.55	2.55	57.4	16.88	311	307	285	278		3/4	279	275	269	264	256	250	238	227	216	204	191	164	147	130	117	104			
1.58	2.53	66.2	19.46	358	354	328	319		7/8	323	318	311	306	296	290	276	264	252	238	224	192	173	154	139	123	111		
1.61	2.52	74.8	22.00	405	400	370	360		1	365	360	352	347	336	329	314	291	288	273	258	221	199	177	160	143	128		
2.43	2.57	40.4	11.86	222	220	207	202	8x6	7/16	199	198	197	195	193	191	188	181	180	178	174	165	156	145	133	121			
2.44	2.56	46.0	13.50	252	250	235	230		1/2	227	226	224	222	220	217	214	207	205	202	198	188	178	166	152	138			
2.46	2.55	51.4	15.12	283	280	263	258		9/16	254	253	251	249	246	243	240	236	232	227	223	212	200	188	173	157			
2.46	2.54	57.0	16.72	312	309	290	284		5/8	281	280	278	275	272	269	265	256	254	252	247	235	222	208	191	173			
2.48	2.53	67.6	19.88	371	368	345	338		3/4	335	333	330	327	324	320	315	305	302	298	293	279	265	247	228	208			
2.50	2.51	78.2	22.96	428	424	398	389		7/8	386	384	381	378	374	370	365	353	350	346	340	324	307	287	265	243			
2.52	2.49	88.4	26.00	485	480	450	440		1	438	435	432	428	424	419	413	401	398	394	385	367	349	327	302	277			
1.45	2.92	42.6	12.50	232	230	215	212	9x4	1/2	206	202	198	192	186	179	171	162	153	142	131	116	101	90	81	71			
1.46	2.91	47.6	14.00	261	258	242	239		9/16	230	225	221	215	209	201	192	182	172	160	148	131	114	101	91	80			
1.47	2.90	52.6	15.46	287	284	265	262		5/8	255	250	245	238	231	222	213	202	191	178	165	146	126	112	101	89			
1.50	2.88	62.6	18.38	341	337	315	311		3/4	303	298	292	284	276	266	255	243	230	216	201	178	154	136	123	109			
1.52	2.86	72.2	21.22	394	389	363	358		7/8	350	345	338	329	320	309	297	283	268	252	235	208	180	160	144	128			
1.55	2.84	81.6	24.00	445	440	410	405		1	397	391	383	374	364	351	338	323	308	289	271	240	208	185	167	148			

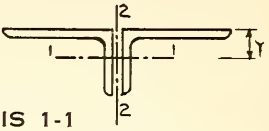
A.I.S.C. 1946 Spec.

Heavy line is for l/r = 120

DOUBLE ANGLE MEMBERS

PROPERTIES AND ALLOWABLE LOADS
TENSION AND COMPRESSION

UNEQUAL ANGLES—LONG LEGS OUT —AXIS 1-1

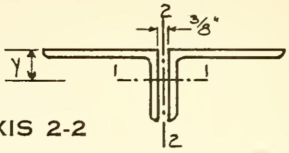


SECTION MODULUS 1-1	RADII OF GYRATION		DISTANCE "X"	WEIGHT 2-LS	AREA 2-LS	NET TENSION 2-ANGLES				SIZE OF ANGLES		Allowable Load, Compression, in Kips, For Length in Feet																	
	r_1	r_2				1-HOLE OUT		2-HOLES OUT				3	4	5	6	7	8	9	10	11	12	13	14	15	16	18	20	22	24
						¾	⅞	¾	⅞																				
0.40	0.60	1.24	0.51	5.50	1.62	26				2½x2	3/16	25	23	20	16	14	12	10	9										
0.50	0.59	1.25	0.54	7.24	2.12	34					¼	32	29	25	21	18	15	13											
0.62	0.58	1.26	0.56	9.00	2.62	42					5/16	40	36	31	26	22	19	16											
0.52	0.57	1.52	0.49	8.20	2.38	39	38			3x2	¼	36	32	28	22	19	17	14											
0.64	0.57	1.53	0.52	10.00	2.94	48	46				5/16	44	40	34	28	24	20	18											
0.74	0.56	1.54	0.54	11.80	3.46	56	54				⅜	52	46	40	32	28	24	20											
0.80	0.75	1.45	0.66	9.00	2.62	44	42	35	32	3x2½	¼	42	39	36	33	29	25	22	19	17	15								
0.98	0.74	1.46	0.68	11.20	3.24	54	52	43	40		5/16	51	48	45	40	35	30	27	24	22	19								
1.16	0.74	1.48	0.71	13.20	3.84	64	62	50	46		⅜	61	58	53	48	41	36	32	28	25	22								
0.82	0.74	1.71	0.61	9.8	2.88	49	47	40	38	3½x2½	¼	45	43	40	36	31	27	24	21	19	17								
1.00	0.73	1.73	0.64	12.2	3.56	60	59	50	46		5/16	57	53	49	44	38	33	30	26	23	20								
1.18	0.72	1.74	0.66	14.4	4.22	71	69	58	54		⅜	68	63	57	51	44	38	34	30	26	23								
1.36	0.71	1.75	0.68	16.6	4.86	82	80	67	62		7/16	77	72	65	58	50	43	39	34	30									
1.52	0.70	1.76	0.70	18.8	5.50	92	90	75	70		½	88	81	73	65	55	48	43	38	33									
1.16	0.91	1.65	0.79	10.8	3.12	54	52	45	42	3½x3	¼	51	49	47	44	40	36	32	29	26	25	21	19						
1.44	0.90	1.66	0.81	13.2	3.86	66	65	56	52		5/16	62	60	57	54	49	44	39	35	32	29	27	24						
1.70	0.90	1.67	0.83	15.8	4.60	79	77	66	62		⅜	75	72	68	64	59	53	46	42	38	34	31	28						
1.96	0.89	1.68	0.85	18.2	5.30	91	88	76	71		7/16	86	83	79	74	67	60	52	47	43	39	36	32						
2.2	0.88	1.70	0.88	20.4	6.00	102	100	85	80		½	97	93	85	83	75	67	59	53	48	43	40	36						
1.20	0.90	1.92	0.74	11.6	3.38	59	58	50	48	4x3	¼	55	53	50	47	43	39	34	31	28	25	23	21						
1.48	0.89	1.93	0.76	14.4	4.18	73	71	62	59		5/16	67	65	62	58	53	47	41	37	34	31	28	25						
1.74	0.88	1.94	0.78	17.0	4.96	86	84	73	69		⅜	80	77	73	68	62	56	49	44	40	36	33	30						
2.0	0.87	1.95	0.80	19.6	5.74	100	97	84	80		7/16	92	89	84	78	71	64	56	50	46	41	38	34						
2.2	0.86	1.96	0.83	22.2	6.50	112	110	95	90		½	105	101	95	88	80	71	62	56	51	46	42	37						
1.62	1.07	1.85	0.91	12.4	3.62	64	62	55	52	4x3½	¼	60	58	56	54	51	47	43	39	36	33	31	28	26	23				
2.0	1.07	1.86	0.93	15.4	4.50	79	78	68	65		5/16	74	72	70	67	63	59	54	49	44	40	37	34	32	29				
2.4	1.06	1.88	0.96	18.2	5.34	94	92	80	76		⅜	87	85	83	79	75	70	64	58	52	47	44	40	37	34				
2.6	1.05	1.89	0.98	21.2	6.18	108	106	93	88		7/16	101	99	95	91	86	80	73	66	59	54	50	46	42	39				
3.0	1.04	1.89	1.00	23.8	7.00	122	120	105	100		½	114	112	108	103	97	90	82	74	66	61	57	52	48	44				
1.22	0.85	2.46	0.66	13.2	3.88	69	67	60	58	5x3	¼	63	60	57	53	48	42	37	33	30	27	24	22						
1.50	0.85	2.47	0.68	16.4	4.80	85	82	74	71		5/16	76	74	70	65	59	52	47	41	37	33	30	27						
1.78	0.84	2.48	0.70	19.6	5.72	101	97	88	84		⅜	92	88	83	77	69	61	55	48	44	39	35	32						
2.0	0.84	2.49	0.73	22.6	6.62	117	112	102	97		7/16	107	102	96	90	81	72	63	57	51	46	41	38						
2.2	0.83	2.50	0.75	25.6	7.50	132	128	115	110		½	120	115	108	101	90	79	71	62	56	50	45							
1.66	1.04	2.37	0.81	14.0	4.12	73	72	65	63	5x3½	¼	68	66	64	61	57	53	49	44	39	36	33	30	28	25				
2.0	1.03	2.38	0.84	17.4	5.12	92	90	81	78		5/16	84	82	79	75	70	65	59	53	48	44	41	37	34	31				
2.4	1.02	2.40	0.86	20.8	6.10	109	107	96	92		⅜	100	97	93	89	83	77	70	63	58	52	48	44	41	37				
2.8	1.01	2.41	0.88	24.0	7.06	126	124	111	106		7/16	116	112	108	103	96	89	81	72	66	60	55	50	46	42				
3.2	1.01	2.43	0.91	27.2	8.00	142	140	125	120		½	131	127	122	116	109	101	92	81	74	67	62	57	53	48				
3.8	0.99	2.45	0.95	33.6	9.84	175	172	153	146		⅝	161	156	149	142	132	122	110	97	89	81	75	68	63	57				
4.4	0.98	2.48	1.00	39.6	11.62	206	202	180	172		¾	190	184	176	167	155	143	129	114	105	96	88	80	74	67				
1.70	1.01	2.93	0.74	15.8	4.62	84	81	75	72	6x3½	¼	76	74	71	67	63	58	53	47	43	39	35	33	30	27				
2.0	1.00	2.94	0.76	19.6	5.74	104	101	93	90		5/16	94	91	87	83	78	72	65	57	53	48	44	40	37	34				
2.4	0.99	2.95	0.79	23.4	6.84	123	119	110	106		⅜	112	108	104	99	92	85	77	68	63	57	52	47	44	40				
3.2	0.97	2.97	0.83	30.6	9.00	162	157	145	140		½	147	142	136	129	120	110	99	88	81	73	67	61	56	51				
2.8	1.18	2.86	0.92	20.6	6.06	111	109	100	96	6x4	5/16	100	98	96	92	88	84	78	73	66	60	55	51	47	44	38			
3.2	1.17	2.87	0.94	24.6	7.22	131	129	118	114		⅜	119	117	114	109	104	99	93	86	78	70	66	61	57	52	45			
3.6	1.16	2.88	0.96	28.6	8.36	152	150	137	132		7/16	138	135	131	127	121	114	107	99	90	81	75	69	65	60	51			
4.2	1.15	2.90	0.99	32.4	9.50	173	170	155	150		½	157	153	148	143	136	129	120	111	101	91	85	78	73	67	58			
4.6	1.14	2.91	1.01	36.2	10.62	193	190	173	168		9/16	176	171	166	160	152	144	134	123	111	101	94	86	80	74	64			
5.0	1.13	2.92	1.03	40.0	11.72	212	209	190	184		⅝	193	189	183	176	167	158	147	135	121	111	103	95	88	81	69			
6.0	1.12	2.95	1.08	47.2	13.88	251	248	225	218		¾	229	224	216	208	198	187	173	159	142	130	121	111	103	95	81			
6.8	1.11	2.97	1.12	54.4	15.96	288	284	258	249		⅞	263	257	248	239	226	213	197	181	162	148	137	126	117	108	92			
3.2	1.13	3.42	0.87	27.2	7.96	146	144	133	129	7x4	⅜	132	128	124	120	114	107	100	92	82	75	70	64	60	55	47			
3.8	1.12	3.43	0.89	31.6	9.24	170	168	155	150		7/16	153	149	144	139	132	124	115	106	94	86	80	74	69	63	54			
4.2	1.11	3.45	0.92	35.8	10.50	193	190	175	170		½	173	169	163	157	149	140	130	119	107	97	90	83	77	71	61			
4.8	1.11	3.46	0.94	40.0	11.74	216	213	196	190		9/16	194	189	182	175	166	156	145	133	119	109	101	92	86	79	68			
5.2	1.10	3.47	0.96	44.2	12.96	238	234	216	209		⅝	214	208	201	193	183	172	159	146	129	120	111	101	94	87	74			
6.0	1.09	3.49	1.01	52.4	15.38	281	278	255	248		¾	253	247	238	229	217	204	188	171	153	141	130	119	111	102	87			
7.0	1.07	3.51	1.05	60.4	17.72	324	319	293	284		⅞	292	284	273	262	247	232	213	193	173	159	147	135	125	115				
3.8	1.09	3.99	0.83	34.4	10.12	187	185	172	167	8x4	7/16	167	163	157	151	143	134	124	113	100	92	85	79	73	67	57			
4.4	1.08	4.00	0.86	39.2	11.50	212	210	195	190		½	188	184	178	171	161	151	140	127	113	104	96	88	81	75	64			
4.8	1.07	4.01	0.88	43.8	12.86	237	235	218	212		9/16	212	206	199	190	180	168	155	140	126	115	106	98	90	83				
5.2	1.07	4.02	0.91	48.4	14.22	262	259	240	234		⅝	234	228	220	211	199	186	172	155	139	127	117	108	99	91				
6.2	1.05	4.04	0.95	57.4	16.88	311	307	285	278		¾	277	270	259	248	235	219	200	180	162	149	136	125	116	106				
7.0	1.04	4.07	1.00	66.2	19.46	358	354	328	319		⅞	320	311	299	286	269	250	228	205	185	170	156	143	131	121				
7.8	1.03	4.10	1.05	74.8	22.00	405	400	370	360		1	361	351	338	322	303	281	257	229	207	190	175	160	146	135				
8.4	1.80	3.68	1.45	40.4	11.86	222	220	207	202	8x6	7/16	199	197	195	192	189	185	181	176	171	165	158	152	144	136	119	107	97	88
9.6	1.79	3.69	1.47	46.0	13.50	252	250	235	230		½	227	225	222	219	215	211	206	200	194	187	180	172	164	154	134	121	110	100
10.6	1.78	3.70	1.50	51.4	15.12	283	280	263	258		9/16	254	252	249	245	241	236	230	224	217	209	200	192	182	172	150	135	123	111
11.8	1.77	3.72	1.52	57.0	16.72	312	309	290	284		⅝	281	278	275	271	266	260	254	247	239	231	221	211	200	189	165	149	135	122
13.8	1.76	3.73	1.56	67.6	19.88	371	368	345	338		¾	334	331	327	322	316	309	302	293	284	273	262	250	237	223	195	176	159	144
15.8	1.74	3.76	1.61	78.2	22.96	428	424	398	389		⅞	385	382	377	371	364	356	347	337	326	314	301	286	271	255	223	201	181	164
17.8	1.73	3.78	1.65	88.4	26.00	485	480	450	440		1	436	432	427	420	412	403	393	381	369	355	339	323	306	287	250	226	203	185
4.4	1.05	4.55	0.81	42.6	12.50	232	230	215	212	9x4	½	206	200	192	184	174	162	148	134	120	110	102	93	86	79				
4.8	1.04	4.56	0.83	47.6	14.00	261	258	242	239		9/16	230	224	216	206	194	181	165	148	133	122	106	103	95	87				
5.2	1.04	4.58	0.86	52.6	15.46	287	284	265	262		⅝	254	247	238	227	214	199	181	163	146	135	123	114	104	96				
6.2	1.02	4.61	0.91	62.6	18.38	341	337	315	311		¾	302	293	282	268	252	234	212	189	171	157	144	132	122	111				
7.2	1.01	4.63	0.95	72.2	21.22	394	389	363	358		⅞	347	338	325	309	290	268	244	216	196	179	165	151	138	127				
8.0	1.00	4.66	1.00	81.6	24.00	445	440	410	405		1	393	382	366	348	326	300	272	240	220	200	184	169	154	142				

A.I.S.C. 1946 Spec.

Heavy line is for
l/r = 120

DOUBLE ANGLE MEMBERS
PROPERTIES AND ALLOWABLE LOADS
TENSION AND COMPRESSION
UNEQUAL LEGS—LONG LEGS OUT—AXIS 2-2



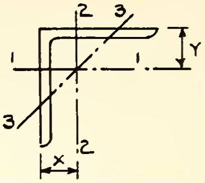
Radii of Gyration		Weight 2-Ls	Area 2-Ls	Net Tension 2-Angles				Size of Angles		Allowable Load, Compression, in Kips, For Length in Feet																		
				1-Hole Out		2-Holes Out																						
r_2	r_1			¾	⅞	¾	⅞			7	8	9	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
1.24	0.60	5.50	1.62	26				2½x2	3/16	24	23	22	20	17	14	13	11	9										
1.25	0.59	7.24	2.12	34					¼	32	30	29	27	22	19	16	14	13										
1.26	0.58	9.00	2.62	42					5/16	39	37	35	33	28	24	21	18	16										
1.52	0.57	8.20	2.38	39	38			3x2	¼	37	36	35	33	30	26	23	20	18	16	14								
1.53	0.57	10.00	2.94	48	46				5/16	45	44	43	41	37	33	28	25	22	20	18								
1.54	0.56	11.80	3.46	56	54				⅜	53	52	51	49	44	39	33	30	27	24	21								
1.45	0.75	9.00	2.62	44	42	35	32	3x2½	¼	40	39	38	36	32	27	24	21	19	17	15								
1.46	0.74	11.20	3.24	54	52	43	40		5/16	50	48	46	44	40	34	30	26	23	21	18								
1.48	0.74	13.20	3.84	64	62	50	46		⅜	59	57	55	53	48	41	36	31	28	25	22								
1.71	0.74	9.8	2.88	49	47	40	38	3½x2½	¼	46	45	44	42	39	35	31	27	24	22	20	18							
1.73	0.73	12.2	3.56	60	59	50	46		5/16	56	55	54	52	49	44	39	34	30	27	25	22	20						
1.74	0.72	14.4	4.22	71	69	58	54		⅜	67	66	64	62	58	53	47	41	37	34	30	27	24						
1.75	0.71	16.6	4.86	82	80	67	62		7/16	77	76	74	71	67	61	54	47	43	39	35	32	28						
1.76	0.70	18.8	5.50	92	90	75	70		½	86	86	84	81	76	69	62	54	49	44	40	36	33						
1.65	0.91	10.8	3.12	54	52	45	42	3½x3	¼	49	48	47	45	42	37	33	28	25	23	20	18							
1.66	0.90	13.2	3.86	66	65	56	52		5/16	60	59	58	56	52	46	41	35	32	28	25	23							
1.67	0.90	15.8	4.60	79	77	66	62		⅜	72	71	69	67	62	56	49	42	39	35	31	28							
1.68	0.89	18.2	5.30	91	88	76	71		7/16	83	82	80	77	72	65	57	50	45	40	36	33							
1.70	0.88	20.4	6.00	102	100	85	80		½	94	93	90	87	81	74	65	57	51	46	42	38							
1.92	0.90	11.6	3.38	59	58	50	48	4x3	¼	54	53	52	51	48	45	41	37	33	30	27	25	23	21	19				
1.93	0.89	14.4	4.18	73	71	62	59		5/16	67	66	64	63	60	56	51	46	40	37	34	31	28	26	23				
1.94	0.88	17.0	4.96	86	84	73	69		⅜	80	78	77	75	71	66	61	54	48	44	40	37	34	31	28				
1.95	0.87	19.6	5.74	100	97	84	80		7/16	93	90	89	87	82	76	70	63	56	51	47	43	39	36	33				
1.96	0.86	22.2	6.50	112	110	95	90		½	104	103	101	99	93	87	80	72	64	58	53	49	44	41	37				
1.85	1.07	12.4	3.62	64	62	55	52	4x3½	¼	58	57	55	54	51	47	53	38	33	30	28	25	23	21					
1.86	1.07	15.4	4.50	79	78	68	65		5/16	72	71	69	68	64	59	53	47	42	38	35	31	29	26					
1.88	1.06	18.2	5.34	94	92	80	76		⅜	85	84	82	80	76	70	64	57	50	46	42	38	35	32					
1.89	1.05	21.2	6.18	108	106	93	88		7/16	99	97	95	93	88	81	74	66	59	53	48	44	40	37					
1.89	1.04	23.8	7.00	122	120	105	100		½	112	110	108	105	99	92	84	75	66	61	55	50	46	42					
2.46	0.85	13.2	3.88	69	67	60	58	5x3	¼	64	63	62	61	60	57	54	51	48	44	40	37	34	32	30	28	26	24	22
2.47	0.85	16.4	4.80	85	82	74	71		5/16	79	78	77	76	73	71	67	64	60	55	50	46	43	40	37	35	32	30	28
2.48	0.84	19.6	5.72	101	97	88	84		⅜	94	93	92	91	88	85	81	76	71	66	60	55	51	48	44	41	38	36	33
2.49	0.84	22.6	6.62	117	112	102	97		7/16	109	108	107	105	102	98	94	88	83	77	70	64	59	55	51	48	45	42	40
2.50	0.83	25.6	7.50	132	128	115	110		½	123	122	121	119	115	111	106	100	94	87	79	72	68	63	58	55	51	48	44
2.37	1.04	14.0	4.12	73	72	65	63	5x3½	¼	68	67	66	65	63	60	57	53	50	45	41	38	35	32	30	28	26	24	22
2.38	1.03	17.4	5.12	92	90	81	78		5/16	84	83	82	81	78	75	71	67	62	57	51	47	44	41	38	35	33	30	27
2.40	1.02	20.8	6.10	109	107	96	92		⅜	100	99	97	96	93	89	85	80	74	68	61	57	53	49	46	42	39	37	34
2.41	1.01	24.0	7.06	126	124	111	106		7/16	116	115	114	112	108	103	99	93	86	79	71	66	61	57	53	49	46	43	40
2.43	1.01	27.2	8.00	142	140	125	120		½	131	130	128	127	122	117	112	105	98	90	81	75	70	65	60	56	52	49	45
2.45	0.99	33.6	9.84	175	172	153	146		⅝	161	160	158	156	151	145	138	130	121	112	101	93	87	80	75	70	65	61	56
2.48	0.98	39.6	11.62	206	202	180	172		¾	191	189	187	184	179	172	164	155	145	134	122	111	103	96	90	83	78	72	68
2.93	1.01	15.8	4.62	84	81	75	72	6x3½	¼	77	76	75	74	73	71	69	66	63	60	57	53	49	45	42	40	38	35	33
2.94	1.00	19.6	5.74	104	101	93	90		5/16	96	95	94	93	91	88	86	82	79	75	71	66	61	56	53	50	47	44	42
2.95	0.99	23.4	6.84	125	119	110	106		⅜	114	113	112	110	108	106	103	99	94	90	85	79	73	67	63	60	56	53	50
2.97	0.97	30.6	9.00	162	157	145	140		½	149	148	147	146	143	139	135	130	125	119	112	105	97	89	84	79	74	70	66
2.86	1.18	20.6	6.06	111	109	100	96	6x4	5/16	100	100	99	98	96	93	90	87	83	79	74	69	64	59	55	52	49	46	43
2.87	1.17	24.6	7.22	131	129	118	114		⅜	120	119	118	117	114	111	108	103	99	94	87	81	75	69	65	61	57	54	51
2.88	1.16	28.6	8.36	152	150	137	132		7/16	139	138	136	135	132	129	125	119	115	109	102	100	87	81	76	71	67	63	59
2.90	1.15	32.4	9.50	173	170	155	150		½	158	156	156	154	150	146	142	136	131	125	116	108	100	92	86	81	77	72	68
2.91	1.14	36.2	10.62	193	190	173	168		9/16	176	175	173	172	168	164	159	152	147	140	130	121	112	104	97	91	86	81	77
2.92	1.13	40.0	11.72	212	209	190	184		⅝	194	193	191	190	185	181	176	168	162	155	144	134	124	115	108	101	95	90	85
2.95	1.12	47.2	13.88	251	248	225	218		¾	230	229	227	225	220	215	208	200	193	184	172	160	149	137	129	121	114	107	100
2.97	1.11	54.4	15.96	288	284	258	249		⅞	266	263	261	260	253	247	240	230	223	213	199	185	172	158	149	140	132	124	118
3.42	1.13	27.2	7.96	146	144	133	129	7x4	⅜	133	132	131	131	128	126	123	120	116	112	108	103	98	93	87	80	76	72	68
3.93	1.12	31.6	9.24	170	168	155	150		7/16	155	154	152	151	149	146	143	139	135	131	126	120	114	108	101	94	88	84	80
3.45	1.11	35.8	10.50	193	190	175	170		½	176	175	174	173	170	167	163	159	154	149	143	137	130	123	115	107	101	96	91
3.46	1.11	40.0	11.74	216	213	196	190		9/16	196	195	194	192	190	186	182	177	172	166	160	153	146	138	129	120	113	108	102
3.47	1.10	44.2	12.96	238	234	216	209		⅝	215	215	214	212	209	205	201	196	190	184	177	169	161	152	143	133	125	119	113
3.49	1.09	52.4	15.38	281	278	255	248		¾	257	256	254	252	249	244	239	233	226	219	211	202	192	182	171	160	150	143	135
3.51	1.07	60.4	17.72	324	319	293	284		⅞	296	295	293	291	287	282	276	269	261	252	243	233	222	210	198	185	173	165	156
3.99	1.09	34.4	10.12	187	185	172	167	8x4	7/16	169	169	168	168	166	164	161	158	154	150	146	142	137	132	126	120	114	108	101
4.00	1.08	39.2	11.50	212	210	195	190		½	193	192	191	191	188	186	183	179	175	171	167	162	156	150	144	137	130	123	115
4.01	1.07	43.8	12.86	237	235	218	212		9/16	216	215	214	213	211	208	205	201	197	192	187	182	176	169	162	155	148	140	131
4.02	1.07	48.4	14.22	262	259	240	234		⅝	239	238	237	236	233	230	226	222	217	212	206	200	194	187	179	171	162	153	143
4.04	1.05	57.4	16.88	311	307	285	278		¾	283	282	281	280	277	273	268	263	258	252	245	238	230	222	213	203	193	182	171
4.07	1.04	66.2	19.46	358	354	328	319		⅞	327	326	325	323	319	315	310	304	298	291	284	275	266	257	247	236	224	212	200
4.10	1.03	74.8	22.00	405	400	370	360		1	369	368	367	365	361	356	351	344	337	329	321	312	302	291	280	268	256	242	228
3.68	1.80	40.4	11.86	222	220	207	202	8x6	7/16	199	198	197	196	193	190	186	182	177	172	166	160	154	147	139	131	123	117	110
3.69	1.79	46.0	13.50	252	250	235	230		½	226	225	224	223	220	216	212	207	202	196	190	183	175	167	159	150	140	133	125
3.70	1.78	51.4	15.12	283	280	263	258		9/16	253	252	251	250	246	242	238	233	227	221	214	206	198	190	180	170	160	150	142
3.72	1.77	57.0	16.72	312	309	290	284		⅝	280	279	278	276	272	268	263	257	250	243	236	227	218	208	198	187	175	166	156
3.73	1.76	67.6	19.88	371	368	345	338		¾	333	332	330	328	324	318	312	305	298	289	280	270	260	248	236	222	208	197	186
3.76	1.74	78.2	22.96	428	424	398	389		⅞	384	383	381	379	374	368	361	353	345	335	325	313	301	288	274	258	243	230	217
3.78	1.73	88.4	26.00	485	480	450	440		1	435	434	432	430	424	417	409	400	391	380	369	356	342	327	312	293	277	262	246
4.55	1.05	42.6	12.50	232	230	215	212	9x4	½	210	209	208	207	206	204	202	199	196	192	188	184	179	174	169	164	158	152	145
4.56	1.04	47.6	14.00	261	258	242	239		9/16	235	234	233	232	231	229	226	223	219	215	211	206	201	196	190	184	177	170	163
4.58	1.04	52.6	15.46	287	284	265	262		⅝	260	259	258	257	256	253	250	246	242	238	233	228	222	216	210	203	196	188	180
4.61	1.02	62.6	18.38	341	337	315	311		¾	309	308	307	306	304	301	297	293	289	284	278	272	266	258	250	242	234	225	216
4.63	1.01	72.2	21.22	394	389	363	358		⅞	358	357	355	353	351	347	343	338	333	327	321	314	306	298	290	281	272	261	250
4.66	1.00	81.6	24.00	445	440	410	405		1	404	403	401	399	396	392	388	383	377	371	364	356	348	339	329	310	308	296	284

A.I.S.C. 1946 Spec.

Heavy line is for l/r = 120

SINGLE ANGLE MEMBERS
PROPERTIES AND ALLOWABLE LOADS
TENSION AND COMPRESSION

EQUAL ANGLES—AXIS 3-3



SECTION MODULUS S_1	SECTION MODULUS S_2	LEAST RAD. GYR.	WEIGHT	AREA	NET TENSION KIPS 1-HOLE OUT ¾	NET TENSION KIPS 1-HOLE OUT ⅞	NET TENSION KIPS 2-HOLES OUT ¾	NET TENSION KIPS 2-HOLES OUT ⅞	SIZE OF ANGLE		Allowable Load, Compression, in Kips, For Length in Feet 3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0.13	0.13	0.40	1.65	0.48					2x2	⅛	6	5	4	3														
0.19	0.19	0.40	2.44	0.71						3/16	9	7	6	5														
0.25	0.25	0.39	3.19	0.94						¼	12	9	7	6														
0.30	0.30	0.39	3.92	1.15						5/16	15	11	9	7														
0.35	0.35	0.39	4.7	1.36						⅜	17	13	11	8														
0.30	0.30	0.49	3.07	0.90	15		12		2½x2½	3/16	13	11	9	7	6	5												
0.39	0.39	0.49	4.1	1.19	20		15			¼	17	15	12	10	8	7												
0.48	0.48	0.49	5.0	1.47	24		18			5/16	21	18	14	12	10	8												
0.57	0.57	0.48	5.9	1.73	28		22			⅜	25	21	17	14	12	10												
0.73	0.73	0.47	7.7	2.25	36		27			½	32	27	21	18	15	13												
0.44	0.44	0.59	3.71	1.09	19	18	15	14	3x3	3/16	17	15	13	11	9	8	7											
0.58	0.58	0.59	4.9	1.44	25	24	20	19		¼	22	20	17	14	12	10	9											
0.71	0.71	0.59	6.1	1.78	30	29	25	23		5/16	27	25	21	18	15	13	11											
0.83	0.83	0.58	7.2	2.11	36	35	29	27		⅜	32	29	25	22	18	15	13											
0.95	0.95	0.58	8.3	2.43	41	40	33	31		7/16	37	33	29	25	20	17	15											
1.1	1.1	0.58	9.4	2.75	46	45	38	35		½	42	38	33	27	23	20	17											
0.79	0.79	0.69	5.8	1.69	30	29	25	24	3½x3½	¼	26	25	23	20	17	15	13	11	10									
0.98	0.98	0.69	7.2	2.09	37	36	31	29		5/16	33	31	28	24	21	18	16	14	12									
1.2	1.2	0.69	8.5	2.48	43	42	36	34		⅜	39	36	33	29	25	22	19	17	15									
1.3	1.3	0.68	9.8	2.87	50	48	42	40		7/16	45	42	38	33	28	25	21	19	17									
1.5	1.5	0.68	11.1	3.25	56	55	48	45		½	51	47	43	38	32	28	24	21	19									
1.0	1.0	0.79	6.6	1.94	35	34	30	29	4x4	¼	31	30	28	25	22	19	17	15	14	12	11							
1.3	1.3	0.79	8.2	2.40	43	42	37	35		5/16	38	36	34	31	28	24	21	19	17	15	14							
1.5	1.5	0.79	9.8	2 86	51	49	44	42		⅜	46	44	41	37	33	28	25	23	20	18	16							
1.8	1.8	0.78	11.3	3.31	58	57	51	48		7/16	53	50	47	43	38	32	29	26	23	21	18							
2.0	2.0	0.78	12.8	3.75	66	65	58	55		½	60	57	53	48	43	37	33	29	26	23	21							
2.4	2.4	0.77	15.7	4.61	81	79	70	67		⅝	73	70	65	59	53	45	40	36	32	28	26							
2.8	2.8	0.77	18.5	5.44	96	94	83	79		¾	87	82	76	69	61	52	47	42	37	33								
2.0	2.0	0.99	10.3	3.03	55	54	50	48	5x5	5/16	50	48	46	44	41	38	34	30	27	25	23	21	19					
2.4	2.4	0.99	12.3	3.61	66	65	59	57		⅜	59	57	55	52	49	45	40	36	33	30	27	25	23	21				
2.8	2.8	0.98	14.3	4.18	76	75	68	66		7/16	68	66	63	60	56	52	46	41	37	34	31	29	26	24				
3.2	3.2	0.98	16.2	4.75	86	85	78	75		½	78	75	72	68	64	59	53	47	43	39	36	33	30	27				
3.9	3.9	0.97	20.0	5.86	106	104	95	92		⅝	96	93	89	84	78	72	64	57	52	48	43	40	36	33				
4.5	4.5	0.97	23.6	6.94	126	124	113	109		¾	113	110	105	100	93	85	76	67	62	56	51	47	43	39				
5.2	5.2	0.96	27.2	7.98	144	142	129	125		⅞	130	126	121	114	105	97	87	77	70	64	58	53	49	45				
3.0	3.0	1.19	12.6	3.66	68	67	63	61	6x6	5/16	61	59	57	56	54	51	47	44	40	36	34	31	29	27	25	23	22	
3.5	3.5	1.19	14.9	4.36	80	79	74	72		⅜	72	71	69	66	64	60	57	53	48	43	40	37	33	32	30	28	26	
4.1	4.1	1.19	17.2	5.06	94	92	86	84		7/16	84	82	79	77	74	70	66	61	56	50	47	43	40	37	35	32	30	
4.6	4.6	1.18	19.6	5.75	106	105	98	95		½	95	93	91	87	84	79	74	69	63	57	53	49	45	42	39	36	34	
5.1	5.1	1.18	21.9	6.43	119	117	109	106		9/16	106	104	101	98	93	89	83	77	70	63	59	55	50	47	43	40	38	
5.7	5.7	1.17	24.2	7.11	131	128	120	115		⅝	118	115	112	108	103	98	91	85	77	70	65	60	55	51	48	44	41	
6.7	6.7	1.17	28.7	8.44	156	154	143	139		¾	140	137	133	128	122	116	108	100	91	83	77	71	66	61	57	52	49	
7.6	7.6	1.17	33.1	9.73	179	177	164	159		⅞	161	157	153	147	141	134	125	116	105	95	88	81	76	70	65	60	56	
8.6	8.6	1.16	37.4	11.00	203	200	185	180		1	182	178	173	167	159	150	141	130	118	107	98	91	85	78	73	68	63	
8.4	8.4	1.58	26.4	7.75	146	145	138	135	8x8	½	130	128	126	123	121	118	114	110	105	100	95	89	83	77	73	68	65	61
9.3	9.3	1.58	29.6	8.68	164	163	155	151		9/16	145	143	141	138	135	132	128	123	118	113	106	100	93	86	81	76	73	68
10.3	10.3	1.58	32.7	9.61	181	179	170	167		⅝	161	159	157	153	150	146	141	136	131	125	118	111	103	95	90	85	80	76
12.2	12.2	1.57	38.9	11.44	216	214	203	199		¾	192	189	186	183	179	174	168	162	155	148	140	131	122	113	106	100	95	90
14.0	14.0	1.56	45.0	13.23	250	247	234	229		⅞	221	219	216	211	206	200	194	187	179	170	161	151	140	130	122	115	109	103
15.8	15.8	1.56	51.0	15.00	283	280	265	260		1	251	248	244	239	234	227	220	212	203	193	182	171	158	147	138	130	124	117
17.5	17.5	1.55	56.9	16.73	315	312	295	289		1⅛	280	277	273	267	260	253	245	236	226	215	203	189	175	162	153	145	137	129

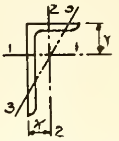
A.I.S.C. 1946 Spec.

Heavy line is for l/r = 120

SINGLE ANGLE MEMBERS

PROPERTIES AND ALLOWABLE LOADS TENSION AND COMPRESSION

UNEQUAL ANGLES—AXIS 3-3

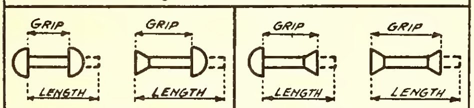


Section Modulus		Least Rad. Gyr.	Weight	Area	Net Tension 2-Angles				Size of Angles		Allowable Load, Compression, in Kips, For Length in Feet																	
S₁	S₂				1-Hole Out ¾	1-Hole Out ⅞	2-Holes Out ¾	2-Holes Out ⅞			3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0.29	0.20	0.43	2.75	0.81	13				2½x2	3/16	11	9	7	6	5													
0.38	0.25	0.42	3.62	1.06	17					¼	14	11	9	7	6													
0.47	0.31	0.42	4.50	1.31	21					5/16	18	14	11	9	7													
0.54	0.26	0.43	4.1	1.19	18				3x2	¼	16	13	10	8	7													
0.66	0.32	0.43	5.0	1.47	24					5/16	20	16	13	10	9													
0.78	0.37	0.43	5.9	1.73	28					⅜	23	19	15	12	10													
0.56	0.40	0.53	4.5	1.31	22	21	18	16	3x2½	¼	19	17	14	12	10	8												
0.69	0.49	0.53	5.6	1.62	27	26	22	20		5/16	24	21	17	14	12	10												
0.81	0.58	0.52	6.6	1.92	32	31	25	23		⅜	28	25	20	17	14	12												
0.75	0.41	0.54	4.9	1.44	25	23	20	19	3½x2½	¼	21	19	16	13	11	9	8											
0.93	0.50	0.54	6.1	1.78	30	29	25	23		5/16	26	23	20	16	14	12	10											
1.1	0.59	0.54	7.2	2.11	35	34	29	27		⅜	31	28	23	19	16	14	12											
1.3	0.68	0.54	8.3	2.43	41	40	34	31		7/16	36	32	27	22	19	16	14											
1.4	0.76	0.53	9.4	2.75	46	45	38	35		½	41	37	31	25	22	18												
0.78	0.58	0.63	5.4	1.56	27	26	23	21	3½x3	¼	24	22	20	17	14	12	11	9										
0.96	0.72	0.63	6.6	1.93	33	32	28	26		5/16	30	27	24	21	18	15	13	11										
1.1	0.85	0.62	7.9	2.30	40	38	33	31		⅜	35	32	29	24	21	18	15	13										
1.3	0.98	0.62	9.1	2.65	45	44	38	35		7/16	41	37	33	28	24	20	18	15										
1.5	1.1	0.62	10.2	3.00	51	50	43	40		½	46	42	37	31	27	23	20	17										
1.0	0.60	0.65	5.8	1.69	30	29	25	24	4x3	¼	26	24	22	19	16	14	12	10										
1.2	0.74	0.65	7.2	2.09	37	36	31	30		5/16	32	30	27	23	20	17	15	13										
1.5	0.87	0.64	8.5	2.48	43	42	37	35		⅜	39	35	32	27	23	20	17	15										
1.7	1.00	0.64	9.8	2.87	50	48	42	40		7/16	45	41	37	31	26	23	20	17										
1.9	1.1	0.64	11.1	3.25	56	55	48	45		½	50	46	41	35	30	26	23	20										
1.0	0.81	0.73	6.2	1.81	32	31	27	26	4x3½	¼	29	27	25	22	19	17	15	13	12	10								
1.3	1.0	0.73	7.7	2.25	40	39	34	32		5/16	36	34	31	28	24	21	18	16	14	13								
1.5	1.2	0.73	9.1	2.67	47	46	40	38		⅜	42	40	37	33	28	24	22	19	17	15								
1.7	1.3	0.72	10.6	3.09	54	53	47	44		7/16	49	46	42	38	32	28	25	22	19	17								
1.9	1.5	0.72	11.9	3.50	61	60	53	50		½	55	52	48	43	36	32	28	25	22	20								
1.5	0.61	0.66	6.6	1.94	35	34	30	29	5x3	¼	30	28	25	22	18	16	14	12	11									
1.9	0.75	0.66	8.2	2.40	43	41	37	35		5/16	37	35	31	27	23	20	17	15	13									
2.2	0.89	0.65	9.8	2.86	51	49	44	42		⅝	44	41	37	31	27	23	20	18										
2.6	1.0	0.65	11.3	3.31	59	56	51	49		7/16	51	47	43	36	31	27	24	21										
2.9	1.1	0.65	12.8	3.75	66	64	58	55		½	58	54	48	41	35	30	27	23										
1.6	0.83	0.76	7.0	2.06	37	36	33	32	5x3½	¼	33	31	29	26	23	20	17	15	14	12								
1.9	1.0	0.76	8.7	2.56	46	45	40	39		5/16	41	39	36	32	28	25	22	19	17	15								
2.3	1.2	0.76	10.4	3.05	55	54	48	46		⅜	49	46	43	39	34	29	26	23	20	18								
2.6	1.4	0.76	12.0	3.53	63	62	55	53		7/16	56	53	49	45	39	34	30	27	24	21								
3.0	1.6	0.75	13.6	4.00	71	70	63	60		½	64	60	56	50	44	38	34	30	27	24								
3.7	1.9	0.75	16.8	4.92	88	86	77	73		⅝	78	74	68	62	54	46	41	37	33	29								
4.3	2.2	0.75	19.8	5.81	103	101	90	86		¾	92	87	81	73	63	55	49	43	38	34								
2.2	0.85	0.78	7.9	2.31	42	41	38	36	6x3½	¼	37	35	33	30	26	23	20	18	16	14	13							
2.7	1.0	0.77	9.8	2.87	52	50	47	45		5/16	46	43	40	37	32	28	25	22	20	18								
3.2	1.2	0.77	11.7	3.42	62	60	55	53		⅜	54	52	48	44	38	33	29	26	23	21								
4.2	1.6	0.76	15.3	4.50	81	79	73	70		½	72	68	63	57	50	43	38	34	30	27								
2.8	1.4	0.88	10.3	9.03	55	54	50	48	6x4	5/16	49	47	45	42	38	34	30	27	24	22	20	18						
3.3	1.6	0.88	12.3	3.61	66	65	59	57		⅜	58	56	53	50	45	41	35	32	29	26	24	21						
3.8	1.8	0.87	14.3	4.18	76	75	68	66		7/16	68	65	61	57	52	46	41	37	33	30	27	25						
4.3	2.1	0.87	16.2	4.75	86	85	77	75		½	77	74	70	65	59	53	46	42	37	34	31	28						
4.8	2.3	0.87	18.1	5.31	96	95	86	84		9/16	86	82	78	73	66	59	52	47	42	38	34	31						
5.3	2.5	0.86	20.0	5.86	106	105	95	92		⅝	95	91	86	80	73	64	56	50	46	41	37	34						
6.2	3.0	0.86	23.6	6.94	126	124	112	109		¾	112	107	102	94	86	76	66	60	54	49	44	40						
7.2	3.4	0.86	27.2	7.98	143	141	128	123		⅞	128	123	116	108	98	87	76	68	63	56	51	46						
4.4	1.6	0.88	13.6	3.99	73	72	67	65	7x4	⅜	64	62	59	55	50	45	39	35	32	29	26	24						
5.1	1.9	0.88	15.8	4.63	85	84	77	75		7/16	75	72	68	64	58	52	45	41	37	33	30	27						
5.8	2.1	0.87	17.9	5.25	96	95	87	85		½	85	82	77	72	66	59	51	46	42	38	34	31						
6.5	2.4	0.87	20.0	5.88	108	106	98	95		9/16	95	91	86	80	73	65	57	51	46	42	38	34						
7.1	2.6	0.86	22.1	6.49	119	117	108	105		⅝	105	100	95	88	80	71	62	56	50	45	41	37						
8.4	3.0	0.86	26.2	7.69	140	139	128	124		¾	124	119	113	105	95	84	74	66	60	54	49	44						
9.7	3.5	0.86	30.2	8.86	162	160	146	142		⅞	143	137	130	120	110	97	85	76	69	62	57	51						
6.6	1.9	0.87	17.2	5.06	94	92	86	84	8x4	7/16	82	79	74	69	63	56	49	44	40	36	33	30						
7.5	2.2	0.86	19.6	5.75	106	105	98	95		½	93	89	84	78	71	63	55	50	45	40	37	33						
8.4	2.4	0.86	21.9	6.43	119	117	109	106		9/16	104	99	94	87	80	70	61	55	50	45	41	37						
9.2	2.6	0.86	24.2	7.11	131	130	120	117		⅝	115	110	104	97	88	78	68	61	55	50	45	41						
10.9	3.1	0.85	28.7	8.44	156	154	142	139		¾	136	130	123	114	104	91	80	72	65	58	53	48						
12.5	3.5	0.85	33.1	9.73	179	177	164	159		⅞	157	150	142	131	119	105	92	83	75	67	61	55						
14.1	3.9	0.85	32.4	11.00	202	200	185	180		1	177	170	160	149	135	119	104	94	85	76	69	62						
7.1	4.2	1.30	20.2	5.93	111	110	104	101	8x6	7/16	99	97	95	92	89	85	81	76	71	65	59	55	52	48	45	42	39	37
8.0	4.8	1.30	23.0	6.75	126	125	118	115		½	112	110	108	105	101	97	92	87	81	75	67	63	59	55	51	48	45	42
8.9	5.3	1.30	25.7	7.56	142	140	132	129		9/16	126	123	121	117	113	109	103	97	91	83	76	71	66	61	57	54	50	47
9.9	5.9	1.30	28.5	8.36	156	154	145	141		⅝	139	136	133	130	125	120	114	108	101	92	84	78	73	68	63	59	56	52
11.7	6.9	1.29	33.8	9.94	186	184	173	169		¾	165	162	158	154	149	142	135	127	118	109	99	91	86	80	75	70	65	61
13.4	7.9	1.28	39.1	11.48	214	212	199	195		⅞	191	187	182	178	171	164	155	146	136	125	113	106	98	92	86	80	75	70
15.1	8.9	1.28	44.2	13.00	243	240	225	220		1	216	212	206	201	194	186	176	165	154	141	128	120	111	104	97	90	85	79
9.3	2.2	0.85	21.3	6.25	116	115	108	106	9x4	½	101	96	91	84	76	67	59	53	48	43	39	35						
10.4	2.4	0.85	23.8	7.00	132	129	121	119		9/16	113	108	102	94	86	76	66	60	53	49	44	40						
11.5	2.6	0.85	26.3	7.73	144	142	133	131		⅝	125	120	113	104	95	84	73	66	59	54	48	44						
13.6	3.1	0.84	31.3	9.19	172	169	158	155		¾	148	142	133	123	112	99	86	77	70	63	57	51						
15.7	3.6	0.84	36.1	10.61	197	194	182	179		⅞	171	164	154	142	129	114	99	89	81	73	65	59						
17.6	4.0	0.83	40.8	12.00	223	220	205	202		1	193	184	174	160	145	126	111	100	90	81	73							

STRUCTURAL RIVETS AND BOLTS

DIMENSIONS AND WEIGHTS

Lengths of Structural Rivets



GRIP	RIVET DIAMETER					
	½	⅝	¾	⅞	1	1¼
½	1⅝	1¾	1⅞	2	2⅛	
⅝	1¾	1⅞	2	2⅛	2¼	
¾	1⅞	2	2⅛	2¼	2⅜	
⅞	2	2⅛	2¼	2⅜	2½	
1	2¼	2⅜	2⅜	2½	2⅝	2⅞
⅛	2⅜	2½	2½	2⅝	2¾	3
¼	2½	2⅝	2⅝	2¾	2⅞	3⅛
⅜	2⅝	2¾	2¾	2⅞	3	3¼
½	2⅞	2⅞	3	3⅛	3¼	3⅜
⅝	3	3	3⅛	3¼	3⅜	3½
¾	3⅛	3¼	3¼	3½	3½	3⅝
⅞	3¼	3⅜	3⅜	3⅝	3⅝	3⅞
2	3½	3½	3⅝	3¾	3¾	4
⅛	3⅝	3⅝	3¾	3⅞	3⅞	4½
¼	3¾	3⅞	3⅞	4	4⅛	4¼
⅜	4	4	4	4⅛	4¼	4⅜
½	4⅛	4⅛	4⅛	4¼	4⅜	4½
⅝	4¼	4¼	4¼	4⅜	4½	4⅝
¾	4⅜	4⅜	4⅜	4½	4⅝	4¾
⅞	4⅝	4⅝	4⅝	4⅝	4¾	4⅞
3		4¾	4¾	4⅞	4⅞	5⅛
⅛		4⅞	4⅞	5	5⅛	5¼
¼		5	5	5⅛	5¼	5⅜
⅜		5⅛	5⅛	5¼	5⅜	5½
½		5⅜	5⅜	5⅜	5½	5⅝
⅝		5½	5½	5½	5⅝	5¾
¾		5⅝	5⅝	5⅝	5¾	5⅞
⅞		5¾	5¾	5¾	5⅞	6
4			5⅞	6	6	6⅛
⅛			6	6⅛	6¼	6¼
¼			6⅛	6¼	6⅜	6⅜
⅜			6⅜	6½	6½	6⅝
½			6½	6⅝	6⅝	6¾
⅝			6⅝	6¾	6¾	6⅞
¾			6¾	6⅞	6⅞	7
⅞			6⅞	7	7	7⅛
5				7⅛	7⅛	7¼
⅛				7¼	7¼	7⅜
¼				7⅜	7⅜	7½
⅜				7⅝	7⅝	7¾
½				7¾	7¾	7⅞
⅝				7⅞	7⅞	8
¾				8	8	8⅛
⅞				8⅛	8⅛	8¼

GRIP	RIVET DIAMETER					
	½	⅝	¾	⅞	1	1¼
½	1	1	1⅛	1¼	1¼	
⅝	1⅛	1¼	1¼	1⅜	1⅜	
¾	1⅜	1⅜	1⅜	1½	1½	
⅞	1½	1½	1½	1⅝	1⅝	
1	1⅝	1⅝	1⅝	1¾	1¾	1⅞
⅛	1¾	1¾	1⅞	1⅞	1⅞	2
¼	2	2	2	2	2	2⅛
⅜	2⅛	2⅛	2⅛	2¼	2¼	2⅜
½	2¼	2¼	2¼	2⅜	2⅜	2½
⅝	2⅜	2⅜	2⅜	2½	2½	2⅝
¾	2⅝	2⅝	2⅝	2⅝	2⅝	2¾
⅞.	2¾	2¾	2¾	2¾	2¾	2⅞
2	2⅞	2⅞	2⅞	2⅞	2⅞	3
⅛	3⅛	3	3	3	3	3⅛
¼	3¼	3⅛	3⅛	3⅛	3¼	3¼
⅜	3⅜	3⅜	3⅜	3⅜	3⅜	3⅜
½	3½	3½	3½	3½	3½	3⅝
⅝	3¾	3⅝	3⅝	3⅝	3⅝	3¾
¾	3⅞	3¾	3¾	3¾	3¾	3⅞
⅞	4	3⅞	3⅞	3⅞	3⅞	4
3		4⅛	4⅛	4⅛	4⅛	4⅛
⅛		4¼	4¼	4¼	4¼	4¼
¼		4⅜	4⅜	4⅜	4⅜	4⅜
⅜		4½	4½	4½	4½	4½
½		4⅝	4⅝	4⅝	4⅝	4⅝
⅝		4¾	4¾	4¾	4¾	4⅞
¾		5	5	5	5	5
⅞		5⅛	5⅛	5⅛	5⅛	5⅛
4			5¼	5¼	5¼	5¼
⅛			5⅜	5⅜	5⅜	5⅜
¼			5½	5½	5½	5½
⅜			5⅝	5⅝	5⅝	5⅝
½			5¾	5¾	5¾	5¾
⅝			6	6	6	6
¾			6⅛	6⅛	6⅛	6⅛
⅞			6¼	6¼	6¼	6¼
5				6⅜	6⅜	6⅜
⅛				6½	6½	6½
¼				6⅝	6⅝	6⅝
⅜				6¾	6¾	6¾
½				6⅞	6⅞	6⅞
⅝				7	7	7
¾				7¼	7¼	7¼
⅞				7⅜	7⅜	7⅜

Weights per 100 Rivets, Lbs.

LENGTH	RIVET DIAMETER							
	⅜	½	⅝	¾	⅞	1	1⅛	1¼
1¼	6	12						
⅜	7	13						
½	7	13	23	35	50	68	91	130
⅝	7	14	24	36	52	71	95	134
¾	8	15	25	37	54	74	98	139
⅞	8	15	26	39	56	77	102	143
2	9	16	27	41	58	80	105	148
⅛	9	17	28	43	60	82	109	152
¼	9	18	29	44	62	85	112	156
⅜	10	18	30	46	64	88	116	161
½	10	19	31	47	67	91	119	165
⅝	11	20	32	49	69	93	123	169
¾	11	20	34	50	71	96	126	174
⅞	11	21	35	52	73	99	130	178
3	12	22	36	54	75	102	133	182
⅛	12	22	37	55	77	105	137	187
¼	13	23	38	57	79	107	141	191
⅜	13	24	39	58	81	110	144	195
½	13	24	40	60	84	113	148	200
⅝	14	25	41	61	86	116	151	204
¾	14	26	42	63	88	118	155	208
⅞	15	27	43	64	90	121	158	213
4	15	27	44	66	92	124	162	217
⅛	15	28	45	68	94	127	165	221
¼	16	29	47	69	96	130	169	226
⅜	16	29	48	71	98	132	172	230
½	16	30	49	72	101	135	176	234
⅝	17	31	50	74	103	138	179	239
¾	17	31	51	75	105	141	183	243
⅞	18	32	52	77	107	143	186	247
5	18	33	53	78	109	146	190	252
⅛	18	34	54	80	111	149	193	256
¼	19	34	55	82	113	152	197	260
⅜	19	35	56	83	115	155	200	265
½	20	36	57	85	118	157	204	269
⅝	20	36	58	86	120	160	207	273
¾	20	37	60	88	122	163	211	278
⅞	21	38	61	89	124	166	214	282
6		38	62	91	126	169	218	287
⅛		39	63	93	128	171	222	291
¼		40	64	94	130	174	225	295
⅜		40	65	96	132	177	229	300
½		41	66	97	135	180	232	304
⅝		42	67	99	137	182	236	308
¾		43	68	100	139	185	239	313
⅞		43	69	102	141	188	243	317
7			70	104	143	191	246	321
⅛			71	105	145	194	250	326
¼			73	107	147	196	253	330
⅜			74	108	149	199	257	334
½			75	110	152	202	260	339
⅝			76	111	154	205	264	343
¾			77	113	156	207	267	347
⅞			78	114	158	210	271	352
8			79	116	160	213	274	356
⅛			80	118	162	216	278	360
¼			81	119	164	219	281	365
⅜			82	121	166	221	285	369
½			83	122	169	224	288	373
⅝			84	124	171	227	292	378
¾			86	125	173	230	295	382
⅞			87	127	175	232	299	386

Dimensions of Bolt Heads and Nuts

DIAMETER OF BOLT	HEAD					DIAMETER OF BOLT	NUT				
	HEXAGON		HEIGHT	SQUARE			HEXAGON		HEIGHT	SQUARE	
	DIAM. IN.			DIAM. IN.			DIAM. IN.			DIAM. IN.	
	LONG	SHORT		LONG	SHORT		LONG	SHORT		LONG	SHORT
¼	7/16	⅜	3/16	½	⅜	¼	9/16	½	¼	11/16	½
⅜	⅝	9/16	¼	¾	9/16	⅜	13/16	11/16	⅜	1	11/16
½	⅞	¾	⅜	1 1/16	¾	½	1	⅞	½	1¼	⅞
⅝	1⅛	15/16	½	1⅜	15/16	⅝	1¼	1 1/16	⅝	1½	1 1/16
¾	1¼	1⅛	9/16	1⅝	1⅛	¾	1½	1¼	¾	1¾	1¼
⅞	1½	1 5/16	⅝	1⅞	1 5/16	⅞	1⅝	1 7/16	⅞	2	1 7/16
1	1¾	1½	¾	2⅛	1½	1	1⅞	1⅝	1	2¼	1⅝
⅛	2	1 11/16	⅞	2⅜	1 11/16	⅛	2⅛	1 13/16	1⅛	2⅝	1 13/16
¼	2⅛	1⅞	15/16	2⅝	1⅞	¼	2¼	2	1¼	2⅞	2
⅜	2⅜	2 1/16	1	2⅞	2 1/16	⅜	2½	2 3/16	1⅜	3⅛	2 3/16
½	2⅝	2¼	1⅛	3⅛	2¼	½	2¾	2⅜	1½	3⅜	2⅜
⅝	3	2 9/16	1¼	3⅝	2 9/16	⅝	3	2 9/16	1⅝	3⅝	2 9/16
¾	3⅛	2¾	1⅜	3⅞	2¾	¾	3⅛	2¾	1¾	3⅞	2¾
⅞	3⅜	2 15/16	1½	4⅛	2 15/16	⅞	3⅜	2 15/16	1⅞	4⅛	2 15/16
2	3⅝	3⅛	1 9/16	4⅜	3⅛	2	3⅝	3⅛	2	4⅜	3⅛
¼	4	3½	1¾	5	3½	¼	4	3½	2¼	5	3½
½	4½	3⅞	1 15/16	5½	3⅞	½	4½	3⅞	2½	5½	3⅞
¾	4⅞	4¼	2⅛	6	4¼	¾	4⅞	4¼	2¾	6	4¼
3	5⅜	4⅝	2 5/16	6½	4⅝	3	5⅜	4⅝	3	6½	4⅝
¼	5¾	5	2½	7	5	¼	5¾	5	3¼	7	5
½	6¼	5⅜	2 11/16	7⅝	5⅜	½	6¼	5⅜	3½	7⅝	5⅜
¾	6⅝	5¾	2⅞	8⅛	5¾	¾	6⅝	5¾	3¾	8⅛	5¾
4	7	6⅛	3 1/16	8⅝	6⅛	4	7	6⅛	4	8⅝	6⅛
¼	7½	6½	3¼	9¼	6½	¼	7½	6½	4¼	9¼	6½
½	8	6⅞	3 7/16	9¾	6⅞	½	8	6⅞	4½	9¾	6⅞
¾	8⅜	7¼	3⅝	10¼	7¼	¾	8⅜	7¼	4¾	10¼	7¼
5	8¾	7⅝	3 13/16	10¾	7⅝	5	8¾	7⅝	5	10¾	7⅝

Bolts—WEIGHT PER 100 HEX. HEADS AND NUTS

LENGTH UNDER HEAD	BOLT DIAMETER				
	½	⅝	¾	⅞	1
1	19	33	52		
¼	20	34	54		
½	22	36	57		
¾	23	38	60		
2	24	40	63	93	132
¼	26	43	66	97	137
½	27	45	69	101	143
¾	29	47	72	105	148
3	30	49	75	109	154
¼	31	51	78	114	160
½	33	54	82	118	165
¾	34	56	85	122	171
4	35	58	88	126	176
¼	37	60	90	130	180
½	38	62	94	134	186
¾	39	64	97	138	191
5	41	66	100	143	197
¼	42	68	103	147	202
½	44	71	106	151	208
¾	45	73	109	156	213
6	46	75	112	160	219
¼	48	77	115	164	225
½	49	79	119	168	230
¾	51	81	122	173	236
7	52	84	125	177	241
¼	53	86	128	181	247
½	55	88	131	185	252
¾	56	90	134	190	258
8	58	92	137	194	264
½	60	96	143	202	274
9	63	100	149	210	285
½	66	105	156	219	296
10	68	109	162	227	307
½	71	114	168	236	318
11	74	118	174	244	329
½	77	122	181	253	341
12	80	127	187	261	352
½	82	131	193	270	363
13	85	135	199	278	374
½	88	139	206	287	385
14	91	144	212	295	396
15	96	152	225	312	418
16	102	161	237	329	441
17	107	170	250	346	463
18	113	177	262	364	485
Add. Per In.	5.6	8.7	12.5	17.0	22.3

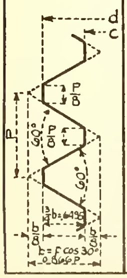
Weight of Rivet Heads

WT. OF 100 BUTTON HEADS	RIVET DIAMETER						
	½	⅝	¾	⅞	1	1⅛	1¼
Manufactured	5.0	9.7	16.0	24.0	35.0	49.0	78.0
Driven	4.0	7.5	12.5	18.5	27.0	37.5	51.0

Weight of Bolt Head and Nut

WEIGHT ONE HEAD AND ONE NUT	BOLT DIAMETER					
	1¼	1½	1¾	2	2½	3
Square	2.05	3.51	5.48	8.08	15.5	26.2
Hexagon	1.73	2.95	4.61	6.79	13.0	22.0
Shank, Per Inch	.348	.501	.682	.890	1.39	2.00

Screw Threads



DIAM.		AREA		NO. THREAD PER IN.
TO'L d	NET c	TOTAL DIA. d	NET DIA. c	
¼	.185	.049	.027	20
⅜	.294	.110	.068	16
½	.400	.196	.126	13
⅝	.507	.307	.202	11
¾	.620	.442	.302	10
⅞	.731	.601	.419	9
1	.838	.785	.551	8
⅛	.939	.994	.693	7
¼	1.064	1.227	.890	7
⅜	1.158	1.485	1.054	6
½	1.283	1.767	1.294	6
⅝	1.389	2.074	1.515	5½
¾	1.490	2.405	1.744	5
⅞	1.615	2.761	2.049	5
2	1.711	3.142	2.300	4½
¼	1.961	3.976	3.021	4½
2½	2.175	4.909	3.716	4
¾	2.425	5.940	4.619	4
3	2.629	7.069	5.428	3½
¼	2.879	8.296	6.509	3½
½	3.100	9.621	7.549	3¼
¾	3.317	11.045	8.641	3
4	3.567	12.566	9.993	3
¼	3.798	14.186	11.330	2⅞
½	4.028	15.904	12.741	2¾
¾	4.255	17.721	14.221	2⅝
5	4.480	19.635	15.766	2½
¼	4.730	21.648	17.574	2½
½	4.953	23.758	19.268	2⅜
¾	5.203	25.967	21.262	2⅜
6	5.423	28.274	23.095	2¼

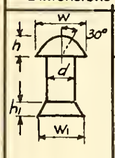
Bolts with Square Heads and Nuts—Weight 100

LENGTH UNDER HEAD	BOLT DIAMETER					
	⅜	½	⅝	¾	⅞	1
1	11	22	37	56		
¼	11	23	39	59		
½	12	24	41	62		
¾	13	26	43	64		
2	14	27	45	67	101	144
¼	15	28	47	71	104	150
½	15	30	49	74	109	155
¾	16	31	51	77	113	161
3	17	33	54	80	117	167
3½	18	35	58	86	126	178
4	20	38	62	92	134	189
4½	21	41	66	98	142	198
5	23	43	71	104	151	209
5½	25	46	75	111	159	220
6	26	49	79	117	168	232
6½	28	52	84	123	176	243
7	29	55	88	129	185	254
8	32	60	97	142	202	276
9	34	65	105	154	218	298
10		71	114	167	235	320
Add. Per In.	3.1	5.6	8.7	12.5	17.0	22.3

PUNCHING AND RIVETING DETAILS

Gages given for beams and channels are for ¾″ rivets.

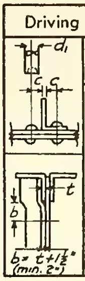
Dimensions of Structural Rivets



$w = 1\frac{1}{2}d + \frac{1}{8}''$
$h = 0.425w$
$r = 1\frac{1}{2}h$

Diam. "d"	w	h	r	w₁	h₁
⅜	11/16	5/16	7/16	9/16	3/16
½	⅞	⅜	9/16	¾	¼
⅝	1 1/16	7/16	11/16	1	5/16
¾	1¼	½	13/16	1 3/16	⅜
⅞	1 7/16	⅝	15/16	1⅜	7/16
1	1⅝	11/16	1	1 9/16	½
1⅛	1 13/16	¾	1⅛	1¾	9/16
1¼	2	⅞	1¼	2	⅝
1⅜	2 3/16	15/16	1⅜	2 3/16	11/16
1½	2⅜	1	1½	2⅜	¾

Driving Clearances

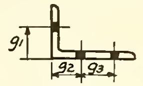

d₁
c c
t
b
b= t+½″
(min. 2″)

Diam. Riv.	Dimension d₁	Dimension c
⅜	1½	⅞
½	1¾	1
⅝	2	1⅛
¾	2¼	1¼
⅞	2½	1⅜
1	2¾	1½
1⅛	3	1⅝
1¼	3¼	1¾
1⅜	3½	1⅞
1½	3¾	2

Rivet Spacing

Diam. Riv.	C. to C. Min.	C. to C. Pref.	Dist. to Shear'd Edge
⅜	1⅛	1¼	⅞
½	1½	1¾	1
⅝	1⅞	2	1⅛
¾	2¼	2½	1¼
⅞	2⅝	3	1½
1	3	3½	1¾
1⅛	3⅜	4	1⅛
1¼	3¾	4½	1¼
1⅜	4⅛	5	1⅜
1½	4½	5½	1½

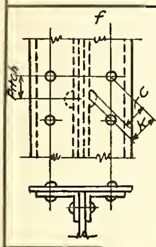
Gages For Angles



x = Max. rivet.

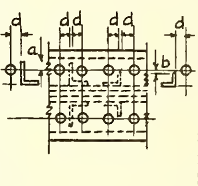
	WIDTH OF LEG, INCHES													
	8	7	6	5	4	3½	3	2½	2	1¾	1½	1⅜	1¼	1
g_1	4½	4	3½	3	2½	2	1¾	1⅜	1⅛	1	⅞	⅞	¾	⅝
g_2	3	2½	2¼	2										
g_3	3	3	2½	1¾										
x	1⅛	1	⅞	⅞	⅞	⅞	⅞	¾	⅝	½	⅜	⅜	⅜	¼

Minimum Pitch for Machine Riveting



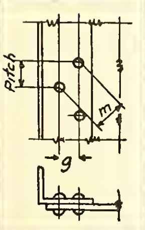
Diam. Riv.	c	k	DISTANCE f, INCHES 1⅛	1¼	1⅜	1½	1⅝	1¾	1⅞	2	2⅛	2¼	2⅜	2½	2¾	3
⅜	⅞	1 3/16	¼	0												
½	1	1⅜	¾	½	0											
⅝	1⅛	1 9/16	1⅛	1	¾	⅜	0									
¾	1¼	1¾		1¼	1⅛	1	¾	0								
⅞	1⅜	2			1½	1⅜	1⅛	⅞	⅝	0						
1	1½	2 3/16				1⅝	1½	1⅜	1⅛	⅞	½	0				
1⅛	1⅝	2⅜					1¾	1⅝	1½	1⅜	1⅛	⅞	0			
1¼	1¾	2⅝						2	1⅞	1¾	1½	1¼	1	⅝	0	
1⅜	1⅞	2 13/16							2⅛	2	1⅞	1¾	1½	1¼	½	0
1½	2	3								2¼	2⅛	2	1⅞	1⅝	1⅛	0

Cover Plate Riveting



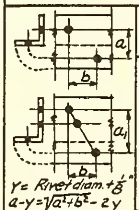
a	d	b	d
½	2½		2½
1	2⅝	½	2⅜
1½	2¾	¾	2¼
2	2¾	1	2¼
2½	2⅞	1¼	2⅛
3	2⅞	1½	2
3½	3	1¾	1¾
4	3⅛	2	1½
5	3¼	2¼	1
6	3⅜	2½	

Minimum Pitch to Maintain 3 Diameters C. to C.



Diam. Riv.	m	DISTANCE g, INCHES 1	1¼	1½	1¾	2	2¼	2½	2¾	3	3¼	3½	3¾	4	4¼	4½
⅜	1⅛	½	0													
½	1½	1⅛	⅞	0												
⅝	1⅞	1⅝	1⅜	1⅛	⅝	0										
¾	2¼	2	1⅞	1⅝	1⅜	1	0									
⅞	2⅝	2½	2⅜	2⅛	2	1¾	1⅜	¾	0							
1	3	2⅞	2¾	2⅝	2½	2¼	2	1⅝	1⅛	0						
1⅛	3⅜	3¼	3⅛	3	2⅞	2¾	2½	2¼	2	1½	⅞	0				
1¼	3¾	3⅝	3½	3⅜	3⅜	3¼	3	2¾	2½	2¼	1⅞	1⅜	0			
1⅜	4⅛	4	4	3⅞	3¾	3⅝	3½	3¼	3⅛	2⅞	2½	2⅛	1¾	1	0	
1½	4½	4⅜	4⅜	4¼	4⅛	4	3⅞	3¾	3½	3⅜	3⅛	2⅞	2½	2	1½	0

Rivet Pitch for Net Section

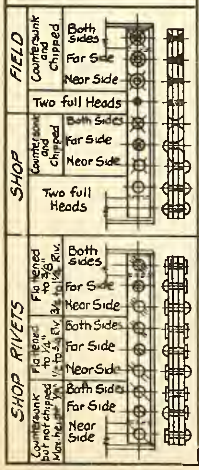


$Y = \text{Rivet diam.} + \frac{1}{8}''$
$a - y = \sqrt{a^2 + b^2} - 2y$
$a_1 - 2y = \sqrt{a^2 + b^2} - 3y$
$b = \sqrt{2ay + y^2}$

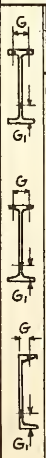
a	b ¾″	b ⅞″	a₁	b ¾″	b ⅞″
1	1⅝	1¾	5	3 1/16	3 5/16
1½	1⅞	2	5½	3¼	3½
2	2 1/16	2¼	6	3⅜	3⅝
2½	2¼	2 7/16	6½	3½	3¾
3	2 7/16	2⅝	7	3⅝	3⅞
3½	2 9/16	2 13/16	7½	3¾	4
4	2 13/16	3	8	3⅞	4⅛
4½	2 15/16	3 3/16	8½	4	4¼

a, a₁ = sum of gages minus thickness of angle

Rivet Conventions

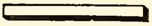

FIELD
Countersunk and Chipped
Both Sides
Far Side
Near Side
Two full Heads
SHOP
Countersunk and Chipped
Both Sides
Far Side
Near Side
Two full Heads
SHOP RIVETS
Flattened to ⅜″ ¾ to 1¼ Riv.
Both sides
Far Side
Near Side
Flattened to ¼″ ½ to ⅝ Riv.
Both Sides
Far Side
Near Side
Countersunk but not chipped Max. height ⅛″
Both Sides
Far Side
Near Side

Gages for Rolled Beams and Channels



CARNEGIE BEAMS								BETHLEHEM BEAMS								STD. I-BEAMS				CHANNELS			
Size	Wt.	G	G₁	Size	Wt.	G	G₁	Size	Wt.	G	G₁	Size	Wt.	G	G₁	Size	Wt.	G	G₁	Size	Wt.	G	G₁
36	230-300	14	3½	16	76-90	9½	2¾	36	230-300	14	4¼	18	47-57	5	2½	24	105.9-120	5½	3¼	15	50-55	2¼	2¾
36	150-192	9½	3	16	58-68	6	2¾	36	150-192	9½	3½	16	76-90	9	2¾	24	79.9-100	4½	3	15	33.9-45	2	2¾
33	200-260	13	3½	16	37-50	4½	2½	33	200-260	13	4	16	58-68	6	2¾	20	81.4-100	4½	3¼	12	35-40	2	2½
33	125-152	9	3	15	85-108	8½	3	33	125-152	9	3¼	16	37-50	4¾	2½	20	65.4-75	4	3	12	20.7-30	1¾	2½
30	180-240	12½	3½	15	35-72	5	2¾	30	180-240	12½	4	15	85-108	8½	3	18	75.6-90	4½	3¼	10	25-35	1¾	2½
30	108-131	8	3	15	35-49	4	2½	30	108-131	8	3	15	35-72	4¼	2¾	18	54.7-70	3½	2¾	10	15.3-20	1½	2½
27	145-175	11½	3	14	142-426	13		28	145-175	11½	3½	14	78-84	9½	2¾	15	81.3-100	4	3¼	9	20-25	1½	2½
27	85-112	7½	2¾	14	87-153	12	2¾	28	85-112	7½	3	14	61-74	7½	2¾	15	60.8-75	3½	3	9	13.4-15	1⅜	2½
24	130-160	11½	3	14	78-84	9½	2½	26	145-171	11½	3½	14	43-58	5½	2½	15	42.9-55	3	2¾	8	16.2-21.2	1½	2¼
24	100-120	9½	2¾	14	61-74	7½	2¾	26	85-101	7	2¾	14	30-42	4¼	2¼	12	40.8-55	3	2¾	8	11.5-13.7	1⅜	2¼
24	85-93	7½	2¾	14	43-58	5½	2½	24	130-160	11½	3¼	12	65-99	9½	2¾	12	31.8-35	3	2½	7	17.2-19.7	1½	2
24	70-81	6½	2½	14	30-42	4	2½	24	100-120	9½	3	12	53-64	7½	2½	10	25.4-40	2¾	2½	7	9.8-14.7	1¼	2
21	101-116	10½	2¾	12	65-190	9½		24	85-93	7½	2¾	12	40-50	5½	2½	9	21.8-35	2½	2½	6	13-15.5	1⅜	2
21	77-96	6½	2¾	12	53-64	7½	2½	24	70-81	6½	2¾	12	55-60	7½	2½	8	18.4-25.5	2¼	2¼	6	8.2-10.5	1⅛	2
21	58-73	5½	2¾	12	40-50	5½	2½	22	101-116	10½	3	12	25-36	4	2¼	7	15.3-20	2¼	2	5	6.7-11.5	1⅛	2
20	115-146	10½	3	12	25-36	4	2½	22	58-96	6	2¾	10	49-89	7½	2¾	6	12.5-17	2	2	4	5.4-7.2	1	1¾
20	74-98	6½	2¾	10	49-136	7½		20	115-146	9½	3¼	10	33-45	5½	2¼	5	10-14.7	1¾	2	3	4.1-6.0	⅞	
20	55-65	5½	2½	10	33-45	5½	2½	20	74-98	6½	3	10	42-45	6½	2½	4	7.7-10.5	1½	1¾				
18	80-99	9	2¾	10	21-29	3	2¼	20	55-65	5½	2½	10	21-29	3¼	2¼	3	5.7-7.5	1½	1¾				
18	64-77	6½	2¾	8	31-67	5½		18	80-99	9¼	3	9	20-23	3	2								
18	47-57	5	2½	8	24-30	4	2¼	18	64-77	6	2¾	8	17-21	2¾	2								

PLATES



WEIGHTS AND AREAS

WEIGHTS

WIDTH IN.	Thickness, Inches												
	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1
¼	.21	.27	.32	.37	.43	.48	.53	.58	.64	.69	.74	.80	.85
½	.43	.53	.64	.74	.85	.96	1.06	1.17	1.28	1.38	1.49	1.59	1.70
¾	.64	.80	.96	1.12	1.28	1.43	1.59	1.75	1.91	2.07	2.23	2.39	2.55
1	.85	1.06	1.28	1.49	1.70	1.91	2.13	2.34	2.55	2.76	2.98	3.19	3.40
2	1.70	2.13	2.55	2.98	3.40	3.83	4.25	4.68	5.10	5.53	5.95	6.38	6.80
3	2.55	3.19	3.83	4.46	5.10	5.74	6.38	7.01	7.65	8.29	8.93	9.56	10.20
4	3.40	4.25	5.10	5.95	6.80	7.65	8.50	9.35	10.20	11.05	11.90	12.75	13.60
5	4.25	5.31	6.38	7.44	8.50	9.56	10.63	11.69	12.75	13.81	14.88	15.94	17.00
6	5.10	6.38	7.65	8.93	10.20	11.48	12.75	14.03	15.30	16.58	17.85	19.13	20.40
7	5.95	7.44	8.93	10.41	11.90	13.39	14.88	16.36	17.85	19.34	20.83	22.31	23.80
8	6.80	8.50	10.20	11.90	13.60	15.30	17.00	18.70	20.40	22.10	23.80	25.50	27.20
9	7.65	9.56	11.48	13.39	15.30	17.21	19.13	21.04	22.95	24.86	26.78	28.69	30.60
10	8.50	10.63	12.75	14.88	17.00	19.13	21.25	23.38	25.50	27.63	29.75	31.88	34.00
11	9.35	11.69	14.03	16.36	18.70	21.04	23.38	25.71	28.05	30.39	32.73	35.06	37.40
12	10.20	12.75	15.30	17.85	20.40	22.95	25.50	28.05	30.60	33.15	35.70	38.25	40.80
13	11.05	13.81	16.58	19.34	22.10	24.86	27.63	30.40	33.20	35.90	38.70	41.40	44.20
14	11.90	14.88	17.85	20.83	23.80	26.78	29.75	32.70	35.70	38.70	41.70	44.60	47.60
15	12.75	15.94	19.13	22.31	25.50	28.69	31.88	35.10	38.30	41.40	44.60	47.80	51.00
16	13.60	17.00	20.40	23.80	27.20	30.60	34.00	37.40	40.80	44.20	47.60	51.00	54.40
17	14.45	18.06	21.68	25.29	28.90	32.51	36.13	39.70	43.40	47.00	50.60	54.20	57.80
18	15.30	19.13	22.95	26.78	30.60	34.43	38.25	42.10	45.90	49.70	53.60	57.40	61.20
19	16.15	20.19	24.23	28.26	32.30	36.34	40.38	44.40	48.50	52.50	56.50	60.60	64.60
20	17.00	21.25	25.50	29.75	34.00	38.25	42.50	46.80	51.00	55.30	59.50	63.80	68.00
21	17.85	22.31	26.78	31.24	35.70	40.16	44.63	49.10	53.60	58.00	62.50	66.90	71.40
22	18.70	23.38	28.05	32.73	37.40	42.08	46.75	51.40	56.10	60.80	65.50	70.10	74.80
23	19.55	24.44	29.33	34.21	39.10	43.99	48.88	53.80	58.70	63.50	68.40	73.30	78.20
24	20.40	25.50	30.60	35.70	40.80	45.90	51.00	56.10	61.20	66.30	71.40	76.50	81.60
25	21.25	26.56	31.88	37.19	42.50	47.81	53.13	58.40	63.80	69.10	74.40	79.70	85.00
26	22.10	27.63	33.15	38.68	44.20	49.73	55.25	60.80	66.30	71.80	77.40	82.90	88.40
27	22.95	28.69	34.43	40.16	45.90	51.64	57.38	63.10	68.90	74.60	80.30	86.10	91.80
28	23.80	29.75	35.70	41.65	47.60	53.55	59.50	65.50	71.40	77.40	83.30	89.30	95.20
29	24.65	30.81	36.98	43.14	49.30	55.46	61.63	67.80	74.00	80.10	86.30	92.40	98.60
30	25.50	31.88	38.25	44.63	51.00	57.38	63.75	70.10	76.50	82.90	89.30	95.60	102.0
31	26.35	32.94	39.53	46.11	52.70	59.29	65.88	72.50	79.10	85.60	92.20	98.80	105.4
32	27.20	34.00	40.80	47.60	54.40	61.20	68.00	74.80	81.60	88.40	95.20	102.0	108.8
33	28.05	35.06	42.08	49.09	56.10	63.11	70.13	77.14	84.15	91.16	98.18	105.2	112.2
34	28.90	36.13	43.35	50.58	57.80	65.03	72.25	79.48	86.70	93.93	101.2	108.4	115.6
35	29.75	37.19	44.63	52.06	59.50	66.94	74.38	81.81	89.25	96.69	104.1	111.6	119.0
36	30.60	38.25	45.90	53.55	61.20	68.85	76.50	84.15	91.80	99.45	107.1	114.8	122.4
37	31.45	39.31	47.18	55.04	62.90	70.76	78.63	86.49	94.35	102.2	110.1	117.9	125.8
38	32.30	40.38	48.45	56.53	64.60	72.68	80.75	88.83	96.90	105.0	113.1	121.1	129.2
39	33.15	41.44	49.73	58.01	66.30	74.59	82.88	91.16	99.45	107.7	116.0	124.3	132.6
40	34.00	42.50	51.00	59.50	68.00	76.50	85.00	93.50	102.0	110.5	119.0	127.5	136.0
41	34.85	43.56	52.28	60.99	69.70	78.41	87.13	95.84	104.6	113.3	122.0	130.7	139.4
42	35.70	44.63	53.55	62.48	71.40	80.33	89.25	98.18	107.1	116.0	125.0	133.9	142.8
43	36.55	45.69	54.83	63.96	73.10	82.24	91.38	100.5	109.7	118.8	127.9	137.1	146.2
44	37.40	46.75	56.10	65.45	74.80	84.15	93.50	102.9	112.2	121.6	130.9	140.3	149.6
45	38.25	47.81	57.38	66.94	76.50	86.06	95.63	105.2	114.8	124.3	133.9	143.4	153.0
46	39.10	48.88	58.65	68.43	78.20	87.98	97.75	107.5	117.3	127.1	136.9	146.6	156.4
47	39.95	49.94	59.93	69.91	79.90	89.89	99.88	109.9	119.9	129.8	139.8	149.8	159.8
48	40.80	51.00	61.20	71.40	81.60	91.80	102.0	112.2	122.4	132.6	142.8	153.0	163.2
49	41.70	52.10	62.50	72.90	83.30	93.70	104.1	114.5	125.0	135.4	145.8	156.2	166.6
50	42.50	53.10	63.80	74.40	86.00	95.60	106.3	116.9	127.5	138.1	148.8	159.4	170.0
51	43.40	54.20	65.00	75.90	86.70	97.50	108.4	119.2	130.1	140.9	151.7	162.6	173.4
52	44.20	55.30	66.30	77.40	88.40	99.50	110.5	121.6	132.6	143.7	154.7	165.8	176.8
53	45.10	56.30	67.60	78.80	90.10	101.4	112.6	123.9	135.2	146.4	157.7	168.9	180.2
54	45.90	57.40	68.90	80.30	91.80	103.3	114.8	126.2	137.7	149.2	160.7	172.1	183.6
55	46.80	58.40	70.10	81.80	93.50	105.2	116.9	128.6	140.3	151.9	163.6	175.3	187.0
56	47.60	59.50	71.40	83.30	95.20	107.1	119.0	130.9	142.8	154.7	166.6	178.5	190.4
57	48.50	60.60	72.70	84.80	96.90	109.0	121.1	133.2	145.4	157.5	169.6	181.7	193.8
58	49.30	61.60	74.00	86.30	98.60	110.9	123.3	135.6	147.9	160.2	172.6	184.9	197.2
59	50.20	62.70	75.20	87.80	100.3	112.8	125.4	137.9	150.5	163.0	175.5	188.1	200.6
60	51.00	63.80	76.50	89.30	102.0	114.8	127.5	140.3	153.0	165.8	178.5	191.3	204.0
61	51.90	64.80	77.80	90.70	103.7	116.7	129.6	142.6	155.6	168.5	181.5	194.4	207.4
62	52.70	65.90	79.10	92.20	105.4	118.6	131.8	144.9	158.1	171.3	184.5	197.6	210.8
63	53.60	66.90	80.30	93.70	107.1	120.5	133.9	147.3	160.7	174.0	187.4	200.8	214.2
64	54.40	68.00	81.60	95.20	108.8	122.4	136.0	149.6	163.2	176.8	190.4	204.0	217.6
65	55.30	69.10	82.90	96.70	110.5	124.3	138.1	151.9	165.8	179.6	193.4	207.2	221.0
66	56.10	70.10	84.20	98.20	112.2	126.2	140.3	154.3	168.3	182.3	196.4	210.4	224.4
67	57.00	71.20	85.40	99.70	113.9	128.1	142.4	156.6	170.9	185.1	199.3	213.6	227.8
68	57.80	72.30	86.70	101.2	115.6	130.1	144.5	159.0	173.4	187.9	202.3	216.8	231.2
69	58.70	73.30	88.00	102.6	117.3	132.0	146.6	161.3	176.0	190.6	205.3	219.9	234.6
70	59.50	74.40	89.30	104.1	119.0	133.9	148.8	163.6	178.5	193.4	208.3	223.1	238.0
71	60.40	75.40	90.50	105.6	120.7	135.8	150.9	166.0	181.1	196.1	211.2	226.3	241.4
72	61.20	76.50	91.80	107.1	122.4	137.7	153.0	168.3	183.6	198.9	214.2	229.5	244.8

AREAS

WIDTH IN.	Thickness, Inches												
	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1
¼	.063	.078	.094	.109	.125	.141	.156	.172	.188	.203	.219	.234	.250
½	.125	.156	.188	.219	.250	.281	.313	.344	.375	.406	.438	.469	.500
¾	.188	.234	.281	.328	.375	.422	.469	.516	.563	.609	.656	.703	.750
1	.250	.313	.375	.438	.500	.563	.625	.688	.750	.813	.875	.938	1.000
2	.50	.63	.75	.88	1.00	1.13	1.25	1.38	1.50	1.63	1.75	1.88	2.00
3	.75	.94	1.13	1.31	1.50	1.69	1.88	2.06	2.25	2.44	2.63	2.81	3.00
4	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00
5	1.25	1.56	1.88	2.19	2.50	2.81	3.13	3.44	3.75	4.06	4.38	4.69	5.00
6	1.50	1.88	2.25	2.63	3.00	3.38	3.75	4.13	4.50	4.88	5.25	5.63	6.00
7	1.75	2.19	2.63	3.06	3.50	3.94	4.38	4.81	5.25	5.69	6.13	6.56	7.00
8	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00
9	2.25	2.81	3.38	3.94	4.50	5.06	5.63	6.19	6.75	7.31	7.88	8.44	9.00
10	2.50	3.13	3.75	4.38	5.00	5.63	6.25	6.88	7.50	8.13	8.75	9.38	10.00
11	2.75	3.44	4.13	4.81	5.50	6.19	6.88	7.56	8.25	8.94	9.63	10.31	11.00
12	3.00	3.75	4.50	5.25	6.00	6.75	7.50	8.25	9.00	9.75	10.50	11.25	12.00
13	3.25	4.06	4.88	5.69	6.50	7.31	8.13	8.94	9.75	10.56	11.38	12.19	13.00
14	3.50	4.38	5.25	6.13	7.00	7.88	8.75	9.63	10.50	11.38	12.25	13.13	14.00
15	3.75	4.69	5.63	6.56	7.50	8.44	9.38	10.31	11.25	12.19	13.13	14.06	15.00
16	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00
17	4.25	5.31	6.38	7.44	8.50	9.56	10.63	11.69	12.75	13.81	14.88	15.94	17.00
18	4.50	5.63	6.75	7.88	9.00	10.13	11.25	12.38	13.50	14.63	15.75	16.88	18.00
19	4.75	5.94	7.13	8.31	9.50	10.69	11.88	13.06	14.25	15.44	16.63	17.81	19.00
20	5.00	6.25	7.50	8.75	10.00	11.25	12.50	13.75	15.00	16.25	17.50	18.75	20.00
21	5.25	6.56	7.88	9.19	10.50	11.81	13.13	14.44	15.75	17.06	18.38	19.69	21.00
22	5.50	6.88	8.25	9.63	11.00	12.38	13.75	15.13	16.50	17.88	19.25	20.63	22.00
23	5.75	7.19	8.63	10.06	11.50	12.94	14.38	15.81	17.25	18.69	20.13	21.56	23.00
24	6.00	7.50	9.00	10.50	12.00	13.50	15.00	16.50	18.00	19.50	21.00	22.50	24.00
25	6.25	7.81	9.38	10.94	12.50	14.06	15.63	17.19	18.75	20.31	21.88	23.44	25.00
26	6.50	8.13	9.75	11.38	13.00	14.63	16.25	17.88	19.50	21.13	22.75	24.38	26.00
27	6.75	8.44	10.13	11.81	13.50	15.19	16.88	18.56	20.25	21.94	23.63	25.31	27.00
28	7.00	8.75	10.50	12.25	14.00	15.75	17.50	19.25	21.00	22.75	24.50	26.25	28.00
29	7.25	9.06	10.88	12.69	14.50	16.31	18.13	19.94	21.75	23.56	25.38	27.19	29.00
30	7.50	9.38	11.25	13.13	15.00	16.88	18.75	20.63	22.50	24.38	26.25	28.13	30.00
31	7.75	9.69	11.63	13.56	15.50	17.44	19.38	21.31	23.25	25.19	27.13	29.06	31.00
32	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	25.00	28.00	30.00	32.00
33	8.25	10.31	12.38	14.44	16.50	18.56	20.63	22.69	24.75	26.81	28.88	30.94	33.00
34	8.50	10.63	12.75	14.88	17.00	19.13	21.25	23.38	25.50	27.63	29.75	31.88	34.00
35	8.75	10.94	13.13	15.31	17.50	19.69	21.88	24.06	26.25	28.44	30.63	32.81	35.00
36	9.00	11.25	13.50	15.75	18.00	20.25	22.50	24.75	27.00	29.25	31.50	33.75	36.00
37	9.25	11.56	13.88	16.19	18.50	20.81	23.13	25.44	27.75	30.06	32.38	34.69	37.00
38	9.50	11.88	14.25	16.63	19.00	21.38	23.75	26.13	28.50	30.88	33.25	35.63	38.00
39	9.75	12.19	14.63	17.06	19.50	21.94	24.38	26.81	29.25	31.69	34.13	36.56	39.00
40	10.00	12.50	15.00	17.50	20.00	22.50	25.00	27.50	30.00	32.50	35.00	37.50	40.00
41	10.25	12.81	15.38	17.94	20.50	23.06	25.63	28.19	30.75	33.31	35.88	38.44	41.00
42	10.50	13.13	15.75	18.38	21.00	23.63	26.25	28.88	31.50	34.13	36.75	39.38	42.00
43	10.75	13.44	16.13	18.81	21.50	24.19	26.88	29.56	32.25	34.94	37.63	40.31	43.00
44	11.00	13.75	16.50	19.25	22.00	24.75	27.50	30.25	33.00	35.75	38.50	41.25	44.00
45	11.25	14.06	16.88	19.69	22.50	25.31	28.13	30.94	33.75	36.56	39.38	42.19	45.00
46	11.50	14.38	17.25	20.13	23.00	25.88	28.75	31.63	34.50	37.38	40.25	43.13	46.00
47	11.75	14.69	17.63	20.56	23.50	26.44	29.38	32.31	35.25	38.19	41.13	44.06	47.00
48	12.00	15.00	18.00	21.00	24.00	27.00	30.00	33.00	36.00	39.00	42.00	45.00	48.00
49	12.25	15.31	18.38	21.44	24.50	27.56	30.63	33.69	36.75	39.81	42.88	45.94	49.00
50	12.50	15.63	18.75	21.88	25.00	28.13	31.25	34.38	37.50	40.63	43.75	46.88	50.00
51	12.75	15.94	19.13	22.31	25.50	28.69	31.88	35.06	38.25	41.44	44.63	47.81	51.00
52	13.00	16.25	19.50	22.75	26.00	29.25	32.50	35.75	39.00	42.25	45.50	48.75	52.00
53	13.25	16.56	19.88	23.19	26.50	29.81	33.13	36.44	39.75	43.06	46.38	49.69	53.00
54	13.50	16.88	20.25	23.63	27.00	30.38	33.75	37.13	40.50	43.88	47.25	50.63	54.00
55	13.75	17.19	20.63	24.06	27.50	30.94	34.38	37.81	41.25	44.69	48.13	51.56	55.00
56	14.00	17.50	21.00	24.50	28.00	31.50	35.00	38.50	42.00	45.50	49.00	52.50	56.00
57	14.25	17.81	21.38	24.94	28.50	32.06	35.63	39.19	42.75	46.31	49.88	53.44	57.00
58	14.50	18.13	21.75	25.38	29.00	32.63	36.25	39.88	43.50	47.13	50.75	54.38	58.00
59	14.75	18.44	22.13	25.81	29.50	33.19	36.88	40.56	44.25	47.94	51.63	55.31	59.00
60	15.00	18.75	22.50	26.25	30.00	33.75	37.50	41.25	45.00	48.75	52.50	56.25	60.00
61	15.25	19.06	22.88	26.69	30.50	34.31	38.13	41.94	45.75	49.56	53.38	57.19	61.00
62	15.50	19.38	23.25	27.13	31.00	34.88	38.75	42.63	46.50	50.38	54.25	58.13	62.00
63	15.75	19.69	23.63	27.56	31.50	35.44	39.38	43.31	47.25	51.19	55.13	59.06	63.00
64	16.00	20.00	24.00	28.00	32.00	36.00	40.00	44.00	48.00	52.00	56.00	60.00	64.00
65	16.25	20.31	24.38	28.44	32.50	36.56	40.63	44.69	48.75	52.81	56.88	60.94	65.00
66	16.50	20.63	24.75	28.88	33.00	37.13	41.25	45.38	49.50	53.63	57.75	61.88	66.00
67	16.75	20.94	25.13	29.31	33.50	37.69	41.88	46.06	50.25	54.44	58.63	62.81	67.00
68	17.00	21.25	25.50	29.75	34.00	38.25	42.50	46.75	51.00	55.25	59.50	63.75	68.00
69	17.25	21.56	25.88	30.19	34.50	38.81	43.13	47.44	51.75	56.06	60.38	64.69	69.00
70	17.50	21.88	26.25	30.63	35.00	39.38	43.75	48.13	52.50	56.88	61.25	65.63	70.00
71	17.75	22.19	26.63	31.06	35.50	39.94	44.38	48.81	53.25	57.69	62.13	66.56	71.00
72	18.00	22.50	27.00	31.50	36.00	40.50	45.00	49.50	54.00	58.50	63.00	67.50	72.00

COURTESY, "AMERICAN INSTITUTE OF STEEL CONSTRUCTION"

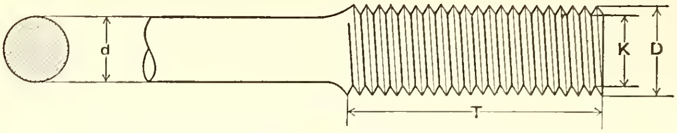
SQUARE AND ROUND BARS

WEIGHT AND AREA

Size Inches	Weight Lb. per Foot		Area Square Inches		Size Inches	Weight Lb. per Foot		Area Square Inches	
	■	●	▨	◍		■	●	▨	◍
0					3	30.60	24.03	9.000	7.069
1/16	.013	.010	.0039	.0031	1/16	31.89	25.05	9.379	7.366
1/8	.053	.042	.0156	.0123	1/8	33.20	26.08	9.766	7.670
3/16	.120	.094	.0352	.0276	3/16	34.54	27.13	10.160	7.980
1/4	.213	.167	.0625	.0491	1/4	35.91	28.21	10.563	8.296
5/16	.332	.261	.0977	.0767	5/16	37.31	29.30	10.973	8.618
3/8	.478	.376	.1406	.1105	3/8	38.73	30.42	11.391	8.946
7/16	.651	.511	.1914	.1503	7/16	40.18	31.55	11.816	9.281
1/2	.850	.668	.2500	.1963	1/2	41.65	32.71	12.250	9.621
9/16	1.076	.845	.3164	.2485	9/16	43.15	33.89	12.691	9.968
5/8	1.328	1.043	.3906	.3068	5/8	44.68	35.09	13.141	10.321
11/16	1.607	1.262	.4727	.3712	11/16	46.23	36.31	13.598	10.680
3/4	1.913	1.502	.5625	.4418	3/4	47.81	37.55	14.063	11.045
13/16	2.245	1.763	.6602	.5185	13/16	49.42	38.81	14.535	11.416
7/8	2.603	2.044	.7656	.6013	7/8	51.05	40.10	15.016	11.793
15/16	2.988	2.347	.8789	.6903	15/16	52.71	41.40	15.504	12.177
1	3.400	2.670	1.0000	.7854	4	54.40	42.73	16.000	12.566
1/16	3.838	3.015	1.1289	.8866	1/16	56.11	44.07	16.504	12.962
1/8	4.303	3.380	1.2656	.9940	1/8	57.85	45.44	17.016	13.364
3/16	4.795	3.766	1.4102	1.1075	3/16	59.62	46.83	17.535	13.772
1/4	5.313	4.172	1.5625	1.2272	1/4	61.41	48.23	18.063	14.186
5/16	5.857	4.600	1.7227	1.3530	5/16	63.23	49.66	18.598	14.607
3/8	6.428	5.049	1.8906	1.4849	3/8	65.08	51.11	19.141	15.033
7/16	7.026	5.518	2.0664	1.6230	7/16	66.95	52.58	19.691	15.466
1/2	7.650	6.008	2.2500	1.7671	1/2	68.85	54.07	20.250	15.904
9/16	8.301	6.519	2.4414	1.9175	9/16	70.78	55.59	20.816	16.349
5/8	8.978	7.051	2.6406	2.0739	5/8	72.73	57.12	21.391	16.800
11/16	9.682	7.604	2.8477	2.2365	11/16	74.71	58.67	21.973	17.257
3/4	10.413	8.178	3.0625	2.4053	3/4	76.71	60.25	22.563	17.721
13/16	11.170	8.773	3.2852	2.5802	13/16	78.74	61.85	23.160	18.190
7/8	11.953	9.388	3.5156	2.7612	7/8	80.80	63.46	23.766	18.665
15/16	12.763	10.024	3.7539	2.9483	15/16	82.89	65.10	24.379	19.147
2	13.600	10.681	4.0000	3.1416	5	85.00	66.76	25.000	19.635
1/16	14.463	11.359	4.2539	3.3410	1/16	87.14	68.44	25.629	20.129
1/8	15.353	12.058	4.5156	3.5466	1/8	89.30	70.14	26.266	20.629
3/16	16.270	12.778	4.7852	3.7583	3/16	91.49	71.86	26.910	21.135
1/4	17.213	13.519	5.0625	3.9761	1/4	93.71	73.60	27.563	21.648
5/16	18.182	14.280	5.3477	4.2000	5/16	95.96	75.36	28.223	22.166
3/8	19.178	15.062	5.6406	4.4301	3/8	98.23	77.15	28.891	22.691
7/16	20.201	15.866	5.9414	4.6664	7/16	100.53	78.95	29.566	23.221
1/2	21.250	16.690	6.2500	4.9087	1/2	102.85	80.78	30.250	23.758
9/16	22.326	17.534	6.5664	5.1572	9/16	105.20	82.62	30.941	24.301
5/8	23.428	18.400	6.8906	5.4119	5/8	107.58	84.49	31.641	24.850
11/16	24.557	19.287	7.2227	5.6727	11/16	109.98	86.38	32.348	25.406
3/4	25.713	20.195	7.5625	5.9396	3/4	112.41	88.29	33.063	25.967
13/16	26.895	21.123	7.9102	6.2126	13/16	114.87	90.22	33.785	26.535
7/8	28.103	22.072	8.2656	6.4918	7/8	117.35	92.17	34.516	27.109
15/16	29.338	23.042	8.6289	6.7771	15/16	119.86	94.14	35.254	27.688
3	30.600	24.033	9.0000	7.0686	6	122.40	96.13	36.000	28.274

COURTESY, "AMERICAN INSTITUTE OF STEEL CONSTRUCTION"

UPSET SCREW ENDS FOR ROUND BARS



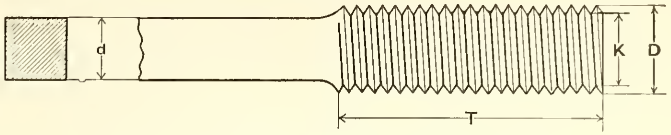
Thread: American Standard Free Fit—Class 2

BAR			UPSET					
Diameter d Inches	Area Sq. In.	Weight per Foot Lb.	Diameter D Inches	Length T Inches	Additional Length for Upset + 10% Inches	Diameter at Root of Thread K Inches	Area	
							At Root of Thread Sq. In.	Excess Over Area of Bar %
* ¾	0.442	1.50	1	4	5	0.838	0.551	24.7
* ⅞	0.601	2.04	1¼	4	5½	1.064	0.890	48.0
1	0.785	2.67	1⅜	4	4	1.158	1.054	34.2
1⅛	0.994	3.38	1½	4	4	1.283	1.294	30.2
1¼	1.227	4.17	1⅝	4	4	1.389	1.515	23.5
1⅜	1.485	5.05	1¾	4	4	1.490	1.744	17.5
1½	1.767	6.01	2	4½	4½	1.711	2.300	30.2
1⅝	2.074	7.05	2⅛	4½	4	1.836	2.649	27.7
1¾	2.405	8.18	2¼	5	4	1.961	3.021	25.6
1⅞	2.761	9.39	2⅜	5	4	2.086	3.419	23.8
2	3.142	10.68	2½	5½	4	2.175	3.716	18.3
2⅛	3.547	12.06	2⅝	5½	3½	2.300	4.156	17.2
2¼	3.976	13.52	2⅞	6	4½	2.550	5.108	28.4
2⅜	4.430	15.06	3	6	4½	2.629	5.428	22.5
2½	4.909	16.69	3¼	6½	5½	2.879	6.509	32.6
2⅝	5.412	18.40	3¼	6½	4½	2.879	6.509	20.3
2¾	5.940	20.19	3½	7	5½	3.100	7.549	27.1
2⅞	6.492	22.07	3¾	7	6	3.317	8.641	33.1
3	7.069	24.03	3¾	7	5	3.317	8.641	22.2
3⅛	7.670	26.08	4	7½	6	3.567	9.993	30.3
3¼	8.296	28.21	4	7½	5	3.567	9.993	20.5
3⅜	8.946	30.42	4¼	8	5½	3.798	11.330	26.6
3½	9.621	32.71	4¼	8	5	3.798	11.330	17.8
3⅝	10.321	35.09	4½	8½	5½	4.028	12.741	23.4
3¾	11.045	37.55	4¾	8½	6	4.255	14.221	28.8
3⅞	11.793	40.10	4¾	8½	5½	4.255	14.221	20.6

*Upsets are special.

COURTESY, "AMERICAN INSTITUTE OF STEEL CONSTRUCTION"

UPSET SCREW ENDS FOR SQUARE BARS



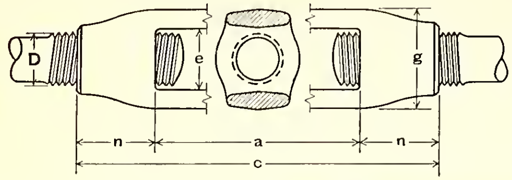
Thread: American Standard Free Fit—Class 2

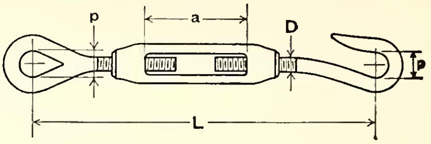
BAR			UPSET					
Side of Square **d** Inches	Area Sq. In.	Weight per Foot Lb.	Diameter D Inches	Length T Inches	Additional Length for Upset +10% Inches	Diameter at Root of Thread K Inches	Area	
							At Root of Thread Sq. In.	Excess Over Area of Bar %
* ¾	0.563	1.91	1⅛	4	4	0.939	0.693	23.2
* ⅞	0.766	2.60	1¼	4	4	1.064	0.890	16.2
1	1.000	3.40	1½	4	4	1.283	1.294	29.4
1⅛	1.266	4.30	1⅝	4	3½	1.389	1.515	19.7
1¼	1.563	5.31	1⅞	4½	4½	1.615	2.049	31.1
1⅜	1.891	6.43	2	4½	4	1.711	2.300	21.7
1½	2.250	7.65	2¼	5	5	1.961	3.021	34.3
1⅝	2.641	8.98	2⅜	5	4½	2.086	3.419	29.5
1¾	3.063	10.41	2½	5½	4½	2.175	3.716	21.3
1⅞	3.516	11.95	2¾	5½	5	2.425	4.619	31.4
2	4.000	13.60	2⅞	6	5	2.550	5.108	27.7
2⅛	4.516	15.35	3	6	4½	2.629	5.428	20.2
2¼	5.063	17.21	3¼	6½	5½	2.879	6.509	28.6
2⅜	5.641	19.18	3½	7	6½	3.100	7.549	33.8
2½	6.250	21.25	3¾	7	7	3.317	8.641	38.3
2⅝	6.891	23.43	3¾	7	5½	3.317	8.641	25.4
2¾	7.563	25.71	4	7½	6½	3.567	9.993	32.1
2⅞	8.266	28.10	4¼	8	7½	3.798	11.330	37.1
3	9.000	30.60	4¼	8	6	3.798	11.330	25.9
3⅛	9.766	33.20	4½	8½	7	4.028	12.741	30.5
3¼	10.563	35.91	4¾	8½	7½	4.255	14.221	34.6

*Upsets are special.

COURTESY, "AMERICAN INSTITUTE OF STEEL CONSTRUCTION"

TURNBUCKLES AND SLEEVE NUTS



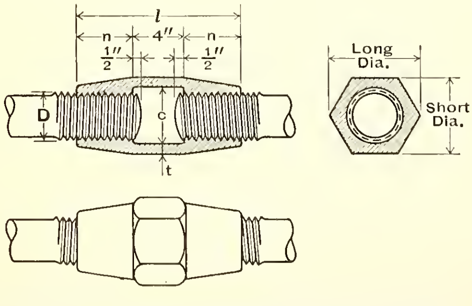


Thread: American Standard Free Fit-Class 2

Size D In.	Standard Turnbuckles					Weight of Turnbuckles, Lb.							Eye and Hook Stubs			
	Dimensions, Inches					Length, a, Inches							Std. p In.	(av.) for a=6″	Weight Lb.	
	a	n	c	e	g	6	9	12	18	24	36	48			Eye	Hook
3/8	6	9/16	7 1/8	9/16	1 1/32	.41							3/4	19	.30	.25
1/2	6	3/4	7 1/2	11/16	1 5/16	.70	.75	1.00					1	19	.61	.48
5/8	6	29/32	7 13/16	13/16	1 1/2	.89	1.38	1.50					1 1/4	19 1/2	1.07	.95
3/4	6	1 1/16	8 1/8	15/16	1 23/32	1.20	1.63	2.13	3.06	4.38			1 1/2	21	1.70	1.52
7/8	6	1 7/32	8 7/16	1 3/32	1 7/8	1.46		2.83	4.33	5.47			1 3/4	23 1/4	2.44	2.19
1	6	1 3/8	8 3/4	1 9/32	2 1/32	2.27		3.80	4.13	4.45	5.12		2	24 1/2	3.42	3.10
1 1/8	6	1 9/16	9 1/8	1 13/32	2 9/32	2.72		4.00	7.25	9.15	12.95		2 1/4	26 1/4	4.92	4.50
1 1/4	6	1 3/4	9 1/2	1 9/16	2 17/32	3.58		4.70	7.13	12.11	16.75		2 1/2	28	6.35	5.82
1 3/8	6	1 15/16	9 7/8	1 11/16	2 3/4	4.13							2 3/4	30	8.42	7.79
1 1/2	6	2 1/8	10 1/4	1 27/32	3 1/32	5.25		8.00	9.13	11.75	17.75	24.00	3	32	10.83	10.08
1 5/8	6	2 1/4	10 1/2	1 31/32	3 9/32	5.88							3 1/4	34	13.91	12.94
1 3/4	6	2 1/2	11	2 1/8	3 9/16	7.05			15.00	21.59	29.35	37.85	3 1/2	35	17.40	16.38
1 7/8	6	2 3/4	11 1/2	2 3/8	4	9.95							3 3/4	37 1/2	20.62	19.45
2	6	2 3/4	11 1/2	2 3/8	4	9.95		15.23		28.35	37.95	48.45	4	40 1/2	25.45	24.13
2 1/4	6	3 3/8	12 3/4	2 11/16	4 5/8	18.00				37.80	51.00	63.95	4 1/2	43 1/2	39.02	37.35
2 1/2	6	3 3/4	13 1/2	3	5	23.25				49.38	65.30	82.50	5	50	57.02	54.94
2 3/4	6	4 1/8	14 1/4	3 1/4	5 5/8	31.50						104.30	5 1/2	55	81.80	79.28
3	6	4 1/2	15	3 5/8	6 1/8	39.50						126.40	6	60	106.06	103.06
3 1/4	6	5 1/4	16 1/2	3 7/8	6 3/4	61.00	70.00									
3 1/2	6	5 1/4	16 1/2	3 7/8	6 3/4	61.00	70.00					203.00				
3 3/4	6	6	18	4 3/4	8 1/2	89.00										
4	6	6	18	4 3/4	8 1/2	89.00						314.00				
4 1/4	9	6 3/4	22 1/2	5 1/4	9 3/4		152.00									
4 1/2	9	6 3/4	22 1/2	5 1/4	9 3/4		152.00									
4 3/4	9	6 3/4	22 1/2	5 1/4	9 3/4		152.00									
5	9	7 1/2	24	6	10		200.00									

Weights and dimensions of Turnbuckles, Eyes and Hooks are Cleveland City Forge Company Standard. Similar products of other companies are essentially the same.

SLEEVE NUTS



Thread: American Standard Free Fit-Class 2
Material: Cast Steel

Dia. of Screw D	Long Dia.	Nut n	Clear c	Short Dia.	Thick-ness t	Length l	Wt.
In.	In.	In.	In.	In.	In.	In.	Lb.
4	7 1/16	4 1/2	4 1/8	6 1/8	1	13	55
4 1/4	7 1/2	4 3/4	4 3/8	6 1/2	1 1/16	13 1/2	65
4 1/2	7 15/16	5	4 3/4	6 7/8	1 1/16	14	75
4 3/4	8 3/8	5 1/4	5	7 1/4	1 1/8	14 1/2	98
5	8 7/8	5 1/2	5 1/4	7 5/8	1 3/16	15	110
5 1/4	9 1/4	5 3/4	5 1/2	8	1 1/4	15 1/2	122
5 1/2	9 3/4	6	5 3/4	8 3/8	1 5/16	16	142
5 3/4	10 1/8	6 1/4	6	8 3/4	1 3/8	16 1/2	157
6	10 5/8	6 1/2	6 1/4	9 1/8	1 7/16	17	176

PIPE

DIMENSIONS							COUPLINGS			PROPERTIES		
Nom. Dia. In.	Outside Dia. In.	Inside Dia. In.	Thickness In.	Weight per Foot Lb.		Threads per Inch	Outside Dia. In.	Length In.	Weight Lb.	I In.^{4}	A In.^{2}	r In.
				Plain Ends	Thread & Cplg.							
STANDARD												
⅛	.405	.269	.068	.24	.25	27	.562	⅞	.03	.001	.072	.12
¼	.540	.364	.088	.42	.43	18	.685	1	.04	.003	.125	.16
⅜	.675	.493	.091	.57	.57	18	.848	1⅛	.07	.007	.167	.21
½	.840	.622	.109	.85	.85	14	1.024	1⅜	.12	.017	.250	.26
¾	1.050	.824	.113	1.13	1.13	14	1.281	1⅝	.21	.037	.333	.33
1	1.315	1.049	.133	1.68	1.68	11½	1.576	1⅞	.35	.087	.494	.42
1¼	1.660	1.380	.140	2.27	2.28	11½	1.950	2⅛	.55	.195	.669	.54
1½	1.900	1.610	.145	2.72	2.73	11½	2.218	2⅜	.76	.310	.799	.62
2	2.375	2.067	.154	3.65	3.68	11½	2.760	2⅝	1.23	.666	1.075	.79
2½	2.875	2.469	.203	5.79	5.82	8	3.276	2⅞	1.76	1.530	1.704	.95
3	3.500	3.068	.216	7.58	7.62	8	3.948	3⅛	2.55	3.017	2.228	1.16
3½	4.000	3.548	.226	9.11	9.20	8	4.591	3⅝	4.33	4.788	2.680	1.34
4	4.500	4.026	.237	10.79	10.89	8	5.091	3⅝	5.41	7.233	3.174	1.51
5	5.563	5.047	.258	14.62	14.81	8	6.296	4⅛	9.16	15.16	4.300	1.88
6	6.625	6.065	.280	18.97	19.19	8	7.358	4⅛	10.82	28.14	5.581	2.25
8	8.625	8.071	.277	24.70	25.00	8	9.420	4⅝	15.84	63.35	7.265	2.95
8	8.625	7.981	.322	28.55	28.81	8	9.420	4⅝	15.84	72.49	8.399	2.94
10	10.750	10.192	.279	31.20	32.00	8	11.721	6⅛	33.92	125.9	9.178	3.70
10	10.750	10.136	.307	34.24	35.00	8	11.721	6⅛	33.92	137.4	10.07	3.69
10	10.750	10.020	.365	40.48	41.13	8	11.721	6⅛	33.92	160.7	11.91	3.67
12	12.750	12.090	.330	43.77	45.00	8	13.958	6⅛	48.27	248.5	12.88	4.39
12	12.750	12.000	.375	49.56	50.71	8	13.958	6⅛	48.27	279.3	14.58	4.38
EXTRA STRONG												
⅛	.405	.215	.095	.31	.32	27	.582	1⅛	.05	.001	.093	.11
¼	.540	.302	.119	.54	.54	18	.724	1⅜	.07	.004	.157	.15
⅜	.675	.423	.126	.74	.75	18	.898	1⅝	.13	.009	.217	.20
½	.840	.546	.147	1.09	1.10	14	1.085	1⅞	.22	.020	.320	.25
¾	1.050	.742	.154	1.47	1.49	14	1.316	2⅛	.33	.045	.433	.32
1	1.315	.957	.179	2.17	2.20	11½	1.575	2⅜	.47	.106	.639	.41
1¼	1.660	1.278	.191	3.00	3.05	11½	2.054	2⅞	1.04	.242	.881	.52
1½	1.900	1.500	.200	3.63	3.69	11½	2.294	2⅞	1.17	.391	1.068	.61
2	2.375	1.939	.218	5.02	5.13	11½	2.870	3⅝	2.17	.868	1.477	.77
2½	2.875	2.323	.276	7.66	7.83	8	3.389	4⅛	3.43	1.924	2.254	.92
3	3.500	2.900	.300	10.25	10.46	8	4.014	4⅛	4.13	3.894	3.016	1.14
3½	4.000	3.364	.318	12.51	12.82	8	4.628	4⅝	6.29	6.280	3.678	1.31
4	4.500	3.826	.337	14.98	15.39	8	5.233	4⅝	8.16	9.610	4.407	1.48
5	5.563	4.813	.375	20.78	21.42	8	6.420	5⅛	12.87	20.67	6.112	1.84
6	6.625	5.761	.432	28.57	29.33	8	7.482	5⅛	15.18	40.49	8.405	2.20
8	8.625	7.625	.500	43.39	44.72	8	9.596	6⅛	26.63	105.7	12.76	2.88
10	10.750	9.750	.500	54.74	56.94	8	11.958	6⅝	44.16	211.9	16.10	3.63
12	12.750	11.750	.500	65.42	68.02	8	13.958	6⅝	51.99	361.5	19.24	4.34
DOUBLE—EXTRA STRONG												
½	.840	.252	.294	1.71	1.73	14	1.085	1⅞	.22	.024	.504	.22
¾	1.050	.434	.308	2.44	2.46	14	1.316	2⅛	.33	.058	.718	.28
1	1.315	.599	.358	3.66	3.68	11½	1.575	2⅜	.47	.140	1.076	.36
1¼	1.660	.896	.382	5.21	5.27	11½	2.054	2⅞	1.04	.341	1.534	.47
1½	1.900	1.100	.400	6.41	6.47	11½	2.294	2⅞	1.17	.568	1.885	.55
2	2.375	1.503	.436	9.03	9.14	11½	2.870	3⅝	2.17	1.311	2.656	.70
2½	2.875	1.771	.552	13.70	13.87	8	3.389	4⅛	3.43	2.871	4.028	.84
3	3.500	2.300	.600	18.58	18.79	8	4.014	4⅛	4.13	5.992	5.466	1.05
3½	4.000	2.728	.636	22.85	23.16	8	4.628	4⅝	6.29	9.848	6.721	1.21
4	4.500	3.152	.674	27.54	27.95	8	5.233	4⅝	8.16	15.28	8.101	1.37
5	5.563	4.063	.750	38.55	39.20	8	6.420	5⅛	12.87	33.64	11.34	1.72
6	6.625	4.897	.864	53.16	53.92	8	7.482	5⅛	15.18	66.33	15.64	2.06
8	8.625	6.875	.875	72.42	73.76	8	9.596	6⅛	26.63	162.0	21.30	2.76

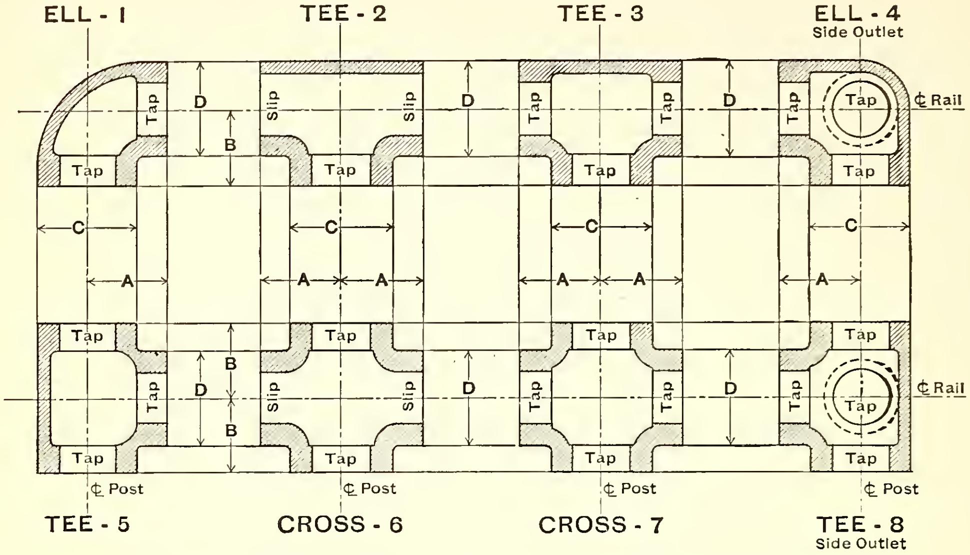
LARGE O. D. PIPE

Pipe 14″ and larger is sold by actual O. S. diameter and thickness.
Sizes 14″, 15″, and 16″ are available regularly in thicknesses varying by 1⁄16″ from ¼″ to 1″, inclusive.

All pipe is furnished random length unless otherwise ordered, viz: 12 to 22 feet with privilege of furnishing 5 per cent in 6 to 12 feet lengths. Pipe railing is most economically detailed with slip joints and random lengths between couplings.

COURTESY, "AMERICAN INSTITUTE OF STEEL CONSTRUCTION"

MALLEABLE IRON PIPE RAILING FITTINGS



Note: Fittings 2 and 6 are for random length pipe with pinned joints.

APPROXIMATE WEIGHTS AND DIMENSIONS

DIMENSIONS, INCHES													
Size of Post	1¼	1½		2			2½			3		3½	
Size of Rail	1¼	1¼	1½	1¼	1½	2	1½	2	2½	2½	3	3	3½
A	1⅝	1⅞	1¾	2⅛	2¼	2¼	2⅝	Same as 2½" pipe with bushing	2¾	3⅜	3⅜	3⅝	3⅝
B	1⅝	2	1¾	2⅜	2½	2¼	2¾		2¾	3½	3⅜	3¾	3⅝
C	2	2⅜	2¼	2¾	2⅞	2¾	3⅜		3⅜	4	4⅛	4½	4⅝
D	2	2⅛	2¼	2	2⅜	2¾	2⅜		3⅜	4	4⅛	4½	4⅝
WEIGHT PER FITTING, LB.													
Ell —1	.7	1.5	.9	1.8	2.0	1.6	4.5	4.2	3.7	6.5	8.0	7.0	8.5
Tee —2	1.2	1.3	1.4	1.8	2.0	2.2	2.3	2.5	3.0	9.2	8.0	10.8	8.7
Tee —3	1.0	1.3	1.1	2.0	2.3	1.9	5.3	5.0	4.6	9.2	8.0	10.8	8.7
Ell —4	1.2	1.3	1.5	2.0	2.1	2.2	2.3	2.8	3.0	9.0	7.5	10.6	10.8
Tee —5	1.0	1.3	1.1	2.0	2.3	1.9	5.3	5.0	4.6	8.2	8.0	9.7	8.8
Cross—6	1.3	1.5	1.6	2.0	2.2	2.3	2.5	3.2	3.3	9.3	8.0	13.8	11.8
Cross—7	1.6	1.8	2.0	2.2	2.4	2.8	......	6.4	5.4	9.3	8.0	13.8	11.8
Tee —8	1.8	1.9	2.0	2.1	2.3	2.8	3.0	3.3	3.5	10.0	8.3	13.6	11.7

Dimensions tabulated above have been rounded out to cover the slight variations which ma occur in standard fittings as supplied by individual manufacturers.

Standard railing fittings are designated by type and sizes of outlets; detail dimensions shoul not appear on material orders.

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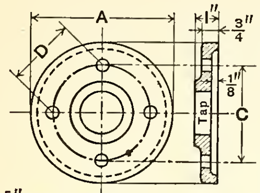
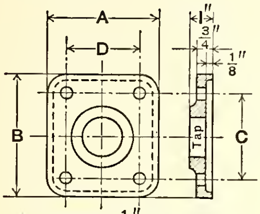
CAST IRON FITTINGS FOR PIPE RAILING



5/8" Cored Holes for Lag Screws or Bolts

FOR WOOD FLOORS

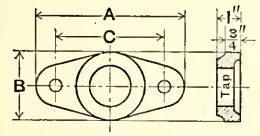
Pipe Size	1¼		1½		2		2½	
O.S. Dia. of Pipe	1.66		1.90		2.375		2.875	
Boss Dia.	2⅛	2⅛	2½	2½	2⅞	2⅞	3⅜	3⅜
A	5¾	7	5¾	7	6½	8	8	8
C	3⅞	Blank	3⅞	Blank	4¼	Blank	5⅝	Blank
D	2¾	Blank	2¾	Blank	3	Blank	4	Blank
Weight, Lb.	4.0	5.6	3.8	5.8	5.0	7.2	6.9	7.0



Drill Holes 1/16" larger than Diameter of Bolts

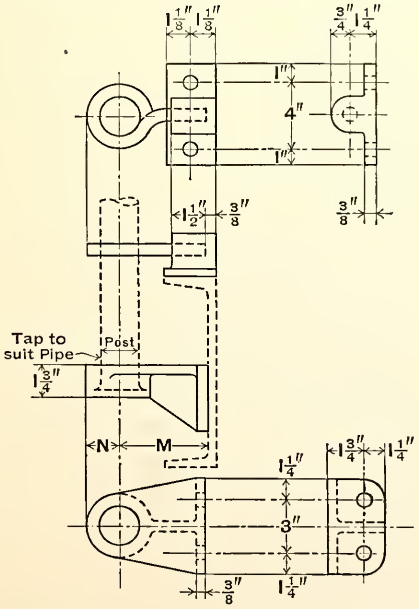
FOR BEAMS

Pipe Size	1¼		1½		2		2½			
O. S. Dia. of Pipe	1.66		1.90		2.375		2.875			
Boss Dia.	2⅛		2½		2⅞		3⅜		3⅜	
A	4¾		4¾		4¾		4¾		6	
B	5¾		5¾		5¾		6½		6	
D	C min.	C max.	C min.	C max.	C min.	C max.	C min.	C max.	C min.	C max.
2¼	3¼	4¼	3¾	4¼	4	4¼				
2½	3	4¼	3½	4¼	4	4¼	4¾	5	4½	4½
2¾	2¾	4¼	3¼	4¼	3¾	4¼	4½	5	4¼	4½
3	2½	4¼	3	4	3½	4	4¼	5	4	4½
3¼	2	4	2¾	3¾	3¼	3¾	4	4¾	4	4½
3½									3¾	4½
4									3¼	4½
4½									2¼	4½
Weight, Lb.	4.3		4.0		3.7		5.0		6.0	



FOR MASONRY AND CONCRETE

Pipe Size	1¼		1½			2		2½			
O. S. Dia. of Pipe	1.66		1.90			2.375		2.875			
Boss Dia.	2⅛	2⅛	2½	2½	2½	2⅞	2⅞	3⅜	3⅜	3⅜	3⅜
A	6	6	6	7	7	7½	7½	8	8	12	12
B	2¾	2¾	3	3	3	3½	3½	4½	4½	4½	4½
C	4½	Blank	4½	5½	Blank	5½	Blank	5½	Blank	9½	Blank
Cored	¾		¾	¾		⅞		⅞		⅞	
Weight, Lb.	1.7	1.7	1.5	2.0	2.0	2.5	2.5	4.9	4.9	5.7	5.7



POST HOLDER AND EYE BOLT

5/8" EYE BOLT TO FIT PIPE CLOSELY.
HOLES CORED 7/8" DIAMETER.
WEIGHT 2.5 LB. WITHOUT EYE BOLT.

POST BRACKET

DRILL HOLES 1/16" LARGER THAN DIAMETER OF BOLT

Size of Pipe	1¼	1½	2	2½
M	4	4	4¼	4½
N	1¼	1⅜	1⅝	1⅞
Weight, Lb.	5.0	6.0	6.2	7.0

COURTESY, "AMERICAN INSTITUTE OF STEEL CONSTRUCTION"

DETAILING PRACTICE

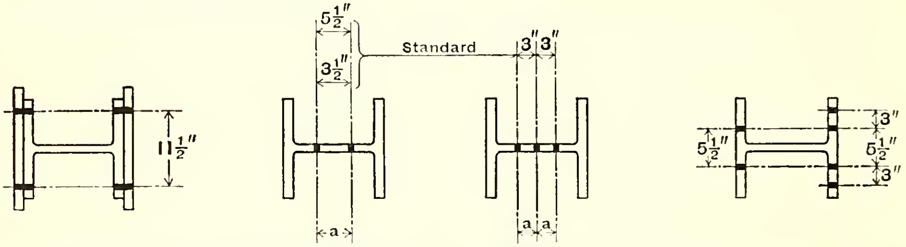
Maximum efficiency in the fabrication of structural steel by modern shops is entirely dependent upon close cooperation between designing office, drafting room and shop. Designs should be favorable to, the drafting room should recognize and call for, and the shop should adapt its equipment to, the use of recurrent details which have been standardized.

Consideration should be given to duplication of details and multiple punching or drilling. Utilization of standard jigs and machine set-ups eliminates unnecessary handling of material and aids drilling or punching holes in groups.

Column gage lines should conform to the standard machine set-ups illustrated below. Once determined they should be duplicated as far as possible throughout any one job. Gages on an individual member should not be varied throughout the length of that member.

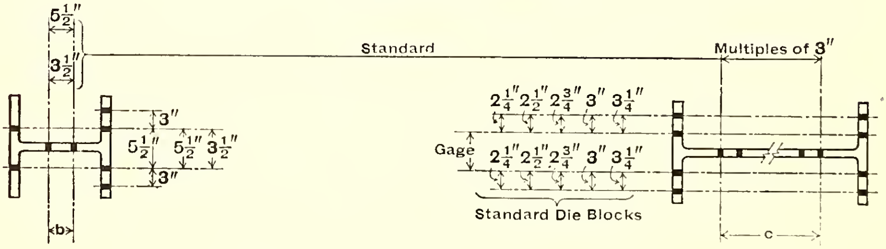
DRILL GAGES

Keep gages and longitudinal spacing alike, if possible, as drilling can be done simultaneously in both flanges.



Minimum "a" = 3″, Maximum "a" controlled by size of member. Gages other than standard should be multiples of 3″.

PUNCH GAGES



Minimum "b" = 2¼″, Maximum "b" controlled by size of member. Gages other than standard should be multiples of 3″. Maximum "c" controlled by size of member.

Longitudinal spacing of holes for both punched and drilled work should be 3″ or multiples of 3″. The adoption of such spacing facilitates the use of multiple drills and punches and makes possible the use of the Standard Beam Connections.

In general the principles governing the selection of gages and longitudinal spacing of holes in beam webs and flanges are identical with those for columns. Sketches and notes for "Punch Gages" apply to all sections. Minimum gages are tabulated under "Dimensions for Detailing."

Beams are connected to columns or other beams by framing angles or they are seated. The need of providing for wind or other bending moments may require a combination of the two. Typical examples of seated and windbracing connections are illustrated on the opposite page.

Standard Beam Connections (A, H, HH, B, K and KK Series) should be used wherever suitable; special heavy connections should be used only when the capacities of Standard Connections are exceeded. Single angle connections should be used only where construction details prevent the use of standard connections.

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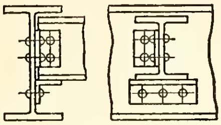
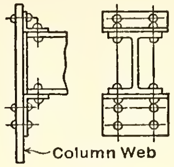
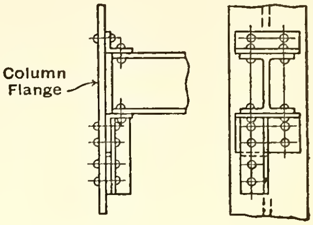
SEATED CONNECTIONS

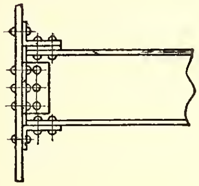


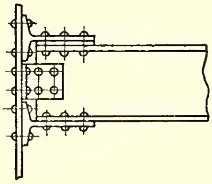


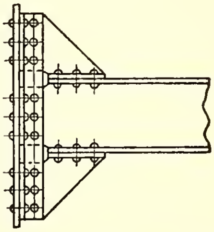


Seated connections without stiffener angles may be used for the values of end reactions up to 35 kips given in the table. Seated connections with single or double stiffeners are used for values of end reactions given in the table or for beams over 18″ in depth. It should be noted that the rivets in the vertical leg determine the capacity of the connection.

WIND BRACING CONNECTIONS



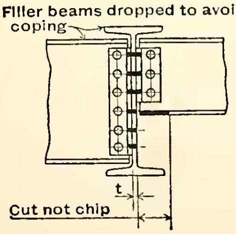


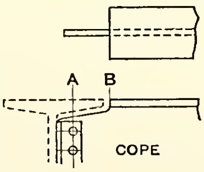


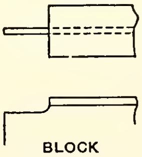
Wind bracing connections, or connections designed to resist bending moments, are usually made with angles or split beams. Brackets are frequently used where architectural features and clearances permit.

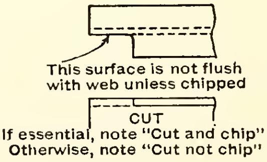
It is essential, for erection purposes, that sufficient clearance be provided between the top angle and top of beam for all seated connections. For top angles riveted to the column allow ¼″ and provide two ⅛″ fills; if the angle is to be shipped loose provide ⅛″ clearance with no fills. To insure web holes matching, beam details should be dimensioned from the bottom flange. Always work with the actual depth of beams, never the nominal.

Where flanges interfere they must be cut as shown to allow insertion of field rivets or bolts.








This surface is not flush with web unless chipped
CUT
If essential, note "Cut and chip"
Otherwise, note "Cut not chip"

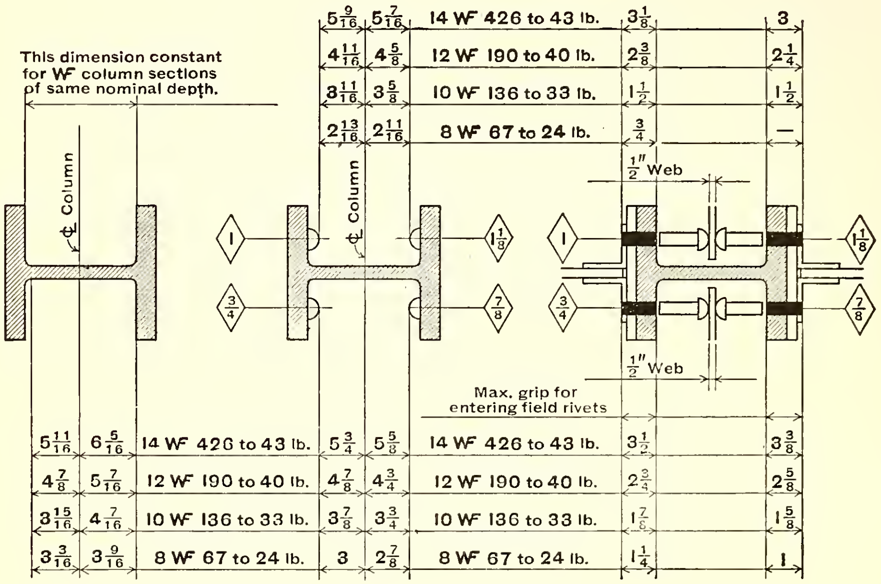
These sketches indicate standard methods of providing clearance for beams connecting to beams or columns. Where possible, a minimum clearance of ½″ is to be provided. Consult fabricator for dimension list of his standard copes and blocks.

Coping or blocking of beams should be avoided wherever possible. When construction will permit, the elevation of the top of filler beams should be established a sufficient distance below the top of girders to clear the thickest girder flange. Unusually long or deep copes and blocks, or blocks in beams with thin webs, may materially affect the capacity of the beam. Such beams must be investigated for both shear and moment at lines A and B and, when necessary, adequate reinforcement provided. Some fabricators designate all the operations pictured above by the term "Cuts."

COURTESY, "AMERICAN INSTITUTE OF STEEL CONSTRUCTION"

FIELD RIVET AND ERECTION CLEARANCES

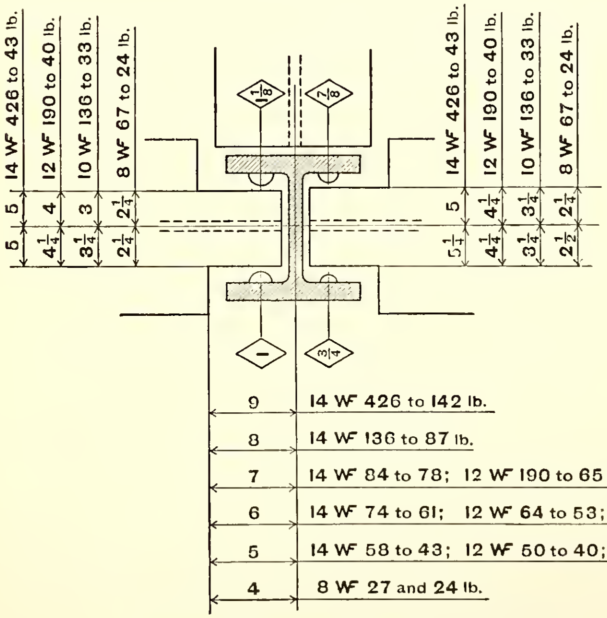
RIVET CLEARANCE—WF COLUMNS


This dimension constant for WF column sections of same nominal depth.
℄ Column
℄ Column
1
$1\frac{1}{8}$
$\frac{3}{4}$
$\frac{7}{8}$
1
$1\frac{1}{8}$
$\frac{3}{4}$
$\frac{7}{8}$
$\frac{1}{2}''$ Web
$\frac{1}{2}''$ Web
Max. grip for entering field rivets

$5\frac{9}{16}$	$5\frac{7}{16}$	14 WF 426 to 43 lb.	$3\frac{1}{8}$	3
$4\frac{11}{16}$	$4\frac{5}{8}$	12 WF 190 to 40 lb.	$2\frac{3}{8}$	$2\frac{1}{4}$
$3\frac{11}{16}$	$3\frac{5}{8}$	10 WF 136 to 33 lb.	$1\frac{1}{2}$	$1\frac{1}{2}$
$2\frac{13}{16}$	$2\frac{11}{16}$	8 WF 67 to 24 lb.	$\frac{3}{4}$	—

$5\frac{11}{16}$	$6\frac{5}{16}$	14 WF 426 to 43 lb.	$5\frac{3}{4}$	$5\frac{5}{8}$	14 WF 426 to 43 lb.	$3\frac{1}{2}$	$3\frac{3}{8}$
$4\frac{7}{8}$	$5\frac{7}{16}$	12 WF 190 to 40 lb.	$4\frac{7}{8}$	$4\frac{3}{4}$	12 WF 190 to 40 lb.	$2\frac{3}{4}$	$2\frac{5}{8}$
$3\frac{15}{16}$	$4\frac{7}{16}$	10 WF 136 to 33 lb.	$3\frac{7}{8}$	$3\frac{3}{4}$	10 WF 136 to 33 lb.	$1\frac{7}{8}$	$1\frac{5}{8}$
$3\frac{3}{16}$	$3\frac{9}{16}$	8 WF 67 to 24 lb.	3	$2\frac{7}{8}$	8 WF 67 to 24 lb.	$1\frac{1}{4}$	1

FLANGE CUTS FOR COLUMN WEB CONNECTIONS


$1\frac{1}{8}$
$\frac{7}{8}$
1
$\frac{3}{4}$

14 WF 426 to 43 lb.	5	5	5	$5\frac{1}{4}$
12 WF 190 to 40 lb.	4	$4\frac{1}{4}$	$4\frac{1}{4}$	$4\frac{1}{4}$
10 WF 136 to 33 lb.	3	$3\frac{1}{4}$	$3\frac{1}{4}$	$3\frac{1}{4}$
8 WF 67 to 24 lb.	$2\frac{1}{4}$	$2\frac{1}{4}$	$2\frac{1}{4}$	$2\frac{1}{2}$

9	14 WF 426 to 142 lb.
8	14 WF 136 to 87 lb.
7	14 WF 84 to 78; 12 WF 190 to 65 lb.
6	14 WF 74 to 61; 12 WF 64 to 53; 10 WF 136 to 49 lb.
5	14 WF 58 to 43; 12 WF 50 to 40; 10 WF 45 to 33; 8 WF 67 to 31 lb.
4	8 WF 27 and 24 lb.

When beams framing to the flanges of columns interfere with beams framing to the web of the column, the latter must be cut as shown.

In all cases where members must be erected by dropping down, allow at least $\frac{1}{2}''$ clearance at rivet heads.

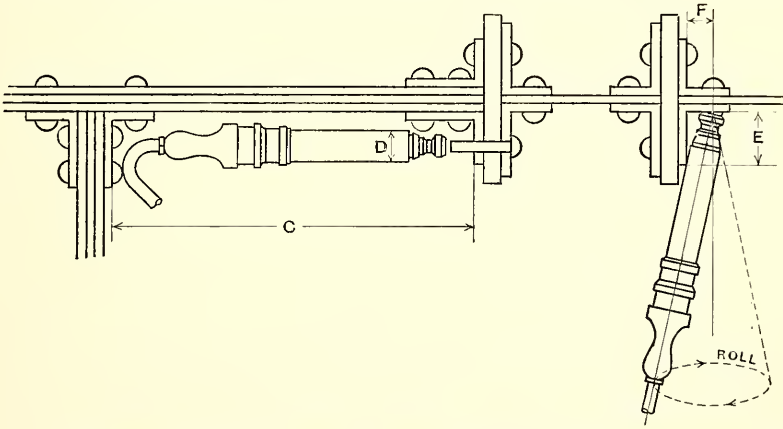
Based on Dimensions of Structural Rivets

COURTESY, "AMERICAN INSTITUTE OF STEEL CONSTRUCTION"

ERECTION CLEARANCES

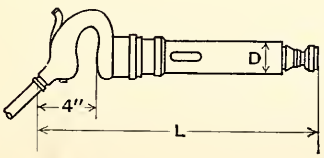
FOR INSERTING AND DRIVING RIVETS

No.	Max. Rivet	Diam. D Ins.	Str. Ins.	Wt. Lbs.	A		B		All hammers except No. 11 can be fitted with inverted handles. These are for crowded work and are only provided by special arrangement.
					Length L Ins.	Clear. C Ins.	Length L₁ Ins.	Clear. C Ins.	
50	¾	$2\frac{5}{16}$	5	20	18	22	14	17	Used only with inverted handle to drive in close quarters.
60	¾	$2\frac{7}{16}$	6	23	19½	24	15½	19	Rarely used.
80	1	$2\frac{7}{16}$	8	25	21½	26	17½	21	Used for all except heaviest riveting.
90	1¼	$2\frac{7}{16}$	9	26	23¾	28	19¾	23	Used for heaviest riveting.
11	1½	$2\frac{7}{16}$	11	32	26½	31	......	......	

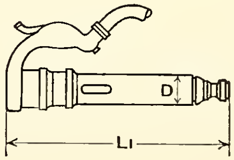


E	F
3″	2″
4	2¼
5	2⅜
6	2⅝
7	2⅞
8	3

If hammer can be "rolled," easier driving and more symmetrical heads are obtained. To permit this, distance "F" must be as given here and field rivets must have a perfect stagger with shop rivets.



A—STANDARD OPEN HANDLE



B—INVERTED HANDLE

TABLE OF PRODUCTS AND SQUARES

NUMBERS VARYING BY SIXTEENTHS

PRODUCT OF FRACTIONS, BY SIXTEENTHS

0	1/16 0.0625	1/8 0.1250	3/16 0.1875	1/4 0.2500	5/16 0.3125	3/8 0.3750	7/16 0.4375	1/2 0.5000	9/16 0.5625	5/8 0.6250	11/16 0.6875	3/4 0.7500	13/16 0.8125	7/8 0.8750	15/16 0.9375	1 1.0000
1/16	.0039															
1/8	.0078	.0156														
3/16	.0117	.0234	.0352													
1/4	.0156	.0313	.0469	.0625												
5/16	.0195	.0391	.0587	.0781	.0977											
3/8	.0234	.0469	.0705	.0937	.1172	.1406										
7/16	.0273	.0547	.0823	.1093	.1367	.1641	.1941									
1/2	.0313	.0625	.0938	.1250	.1562	.1875	.2188	.2500								
9/16	.0352	.0703	.1056	.1406	.1757	.2110	.2462	.2813	.3164							
5/8	.0391	.0781	.1172	.1562	.1952	.2343	.2734	.3125	.3516	.3909						
11/16	.0430	.0859	.1289	.1718	.2148	.2578	.3007	.3438	.3867	.4297	.4727					
3/4	.0469	.0938	.1406	.1875	.2344	.2813	.3281	.3750	.4219	.4686	.5156	.5625				
13/16	.0508	.1016	.1523	.2031	.2539	.3047	.3555	.4063	.4570	.5078	.5586	.6094	.6601			
7/8	.0547	.1094	.1640	.2187	.2734	.3281	.3828	.4375	.4922	.5469	.6016	.6563	.7109	.7656		
15/16	.0586	.1172	.1757	.2343	.2929	.3515	.4102	.4688	.5274	.5859	.6445	.7031	.7617	.8203	.8789	
1	.0625	.1250	.1875	.2500	.3125	.3750	.4375	.5000	.5625	.6250	.6875	.7500	.8125	.8750	.9375	1.0000

SQUARES OF NUMBERS, VARYING BY SIXTEENTHS

	0	1/16 0.0625	1/8 0.1250	3/16 0.1875	1/4 0.2500	5/16 0.3125	3/8 0.3750	7/16 0.4375	1/2 0.5000	9/16 0.5625	5/8 0.6250	11/16 0.6875	3/4 0.7500	13/16 0.8125	7/8 0.8750	15/16 0.9375
1	1.00	1.13	1.27	1.41	1.56	1.72	1.89	2.07	2.25	2.44	2.64	2.85	3.06	3.29	3.52	3.75
2	4.00	4.25	4.52	4.79	5.06	5.35	5.64	5.94	6.25	6.57	6.89	7.22	7.56	7.91	8.27	8.63
3	9.00	9.38	9.77	10.16	10.56	10.97	11.39	11.82	12.25	12.69	13.14	13.60	14.06	14.54	15.02	15.50
4	16.00	16.50	17.02	17.54	18.06	18.60	19.14	19.70	20.25	20.82	21.39	21.97	22.56	23.16	23.77	24.38
5	25.00	25.63	26.27	26.91	27.56	28.22	28.89	29.57	30.25	30.94	31.65	32.35	33.06	33.79	34.52	35.25
6	36.00	36.75	37.52	38.29	39.06	39.85	40.64	41.44	42.25	43.07	43.89	44.72	45.56	46.41	47.27	48.13
7	49.00	49.88	50.77	51.66	52.56	53.47	54.39	55.32	56.25	57.19	58.14	59.10	60.06	61.04	62.02	63.00
8	64.00	65.00	66.02	67.04	68.06	69.10	70.14	71.19	72.25	73.32	74.39	75.47	76.56	77.66	78.77	79.88
9	81.00	82.13	83.27	84.41	85.56	86.72	87.89	89.07	90.25	91.44	92.64	93.85	95.06	96.29	97.52	98.75
10	100.00	101.25	102.52	103.79	105.06	106.35	107.64	108.94	110.25	111.57	112.89	114.22	115.56	116.91	118.26	119.63
11	121.00	122.38	123.77	125.16	126.56	127.97	129.39	130.82	132.25	133.69	135.14	136.60	138.06	139.54	141.02	142.50
12	144.00	145.50	147.01	148.54	150.06	151.60	153.16	154.69	156.25	157.81	159.39	160.98	162.56	164.16	165.76	167.39
13	169.00	170.63	172.27	173.91	175.57	177.22	178.89	180.56	182.25	183.95	185.65	187.34	189.06	190.79	192.51	194.26
14	196.00	197.76	199.51	201.28	203.07	204.85	206.64	208.44	210.25	212.07	213.90	215.73	217.57	219.41	221.27	223.13
15	225.00	226.87	228.77	230.66	232.56	234.48	236.39	238.32	240.25	242.19	244.14	246.10	248.07	250.04	252.01	254.00
16	256.00	258.01	260.02	262.04	264.07	266.10	268.14	270.19	272.25	274.32	276.39	278.47	280.58	282.66	284.76	286.88
17	289.00	291.13	293.27	295.42	297.56	299.72	301.90	304.07	306.25	308.45	310.64	312.85	315.06	317.29	319.52	321.75
18	324.00	326.26	328.52	330.78	333.06	335.35	337.64	339.94	342.25	344.56	346.90	349.23	351.56	353.91	356.27	358.63
19	361.00	363.38	365.76	368.17	370.56	372.97	375.39	377.81	380.25	382.69	385.14	387.61	390.07	392.53	395.02	397.50
20	400.00	402.51	405.01	407.53	410.07	412.60	415.14	417.69	420.25	422.81	425.39	427.97	430.56	433.17	435.77	438.38
21	441.00	443.64	446.27	448.91	451.57	454.22	456.90	459.56	462.25	464.95	467.64	470.35	473.07	475.79	478.51	481.25
22	484.00	486.75	489.51	492.28	495.06	497.85	500.65	503.44	506.25	509.07	511.89	514.73	517.57	520.42	523.27	526.13
23	529.00	531.88	534.77	537.67	540.56	543.47	546.39	549.32	552.25	555.19	558.14	561.10	564.06	567.03	570.01	573.01
24	576.00	579.01	582.02	585.03	588.07	591.09	594.14	597.20	600.25	603.32	606.38	609.47	612.56	615.66	618.77	621.88
25	625.00	628.13	631.27	634.41	637.56	640.73	643.90	647.06	650.25	653.44	656.64	659.85	663.06	666.29	669.51	672.75
26	676.00	679.25	682.52	685.79	689.07	692.35	695.64	698.95	702.25	705.57	708.90	712.22	715.57	718.91	722.26	725.63
27	729.00	732.38	735.77	739.17	742.57	745.98	749.39	752.82	756.25	759.69	763.14	766.60	770.07	773.04	777.01	780.51
28	784.00	787.51	791.02	794.53	798.06	801.61	805.15	808.69	812.25	815.82	819.39	822.97	826.56	830.16	833.76	837.37
29	841.00	844.63	848.26	851.90	855.56	859.22	862.89	866.56	870.25	873.94	877.64	881.35	885.07	888.78	892.51	896.26
30	900.00	903.76	907.52	911.29	915.06	918.85	922.64	926.44	930.25	934.07	937.89	941.72	945.56	949.41	953.27	957.13
31	961.0	964.9	968.8	972.7	976.6	980.5	984.4	988.3	992.3	996.2	1000.1	1004.1	1008.1	1012.0	1016.0	1020.0
32	1024.0	1028.0	1032.0	1036.0	1040.1	1044.1	1048.2	1052.2	1056.3	1060.3	1064.4	1068.5	1072.6	1076.7	1080.8	1084.9
33	1089.0	1093.1	1097.3	1101.4	1105.6	1109.7	1113.9	1118.1	1122.3	1126.4	1130.7	1134.9	1139.1	1143.3	1147.5	1151.8
34	1156.0	1160.3	1164.5	1168.8	1173.1	1177.3	1181.6	1185.9	1190.3	1194.6	1198.9	1203.2	1207.6	1211.9	1216.3	1220.6
35	1225.0	1229.4	1233.8	1238.2	1242.6	1247.0	1251.4	1255.8	1260.3	1264.7	1269.1	1273.6	1278.1	1282.5	1287.0	1291.5
36	1296.0	1300.5	1305.0	1309.5	1314.1	1318.6	1323.1	1327.7	1332.3	1336.8	1341.4	1346.0	1350.6	1355.2	1359.8	1364.4
37	1369.0	1373.6	1378.3	1382.9	1387.8	1392.2	1396.9	1401.6	1406.3	1410.9	1415.6	1420.3	1425.1	1429.8	1434.5	1439.3
38	1444.0	1448.8	1453.5	1458.3	1463.1	1467.9	1472.6	1477.4	1482.3	1487.1	1491.9	1496.7	1501.6	1506.4	1511.3	1516.1
39	1521.0	1525.9	1530.8	1535.7	1540.6	1545.5	1550.4	1555.3	1560.3	1565.2	1570.2	1575.1	1580.1	1585.0	1590.0	1595.0
40	1600.0	1605.0	1610.0	1615.0	1620.1	1625.1	1630.1	1635.2	1640.3	1645.3	1650.4	1655.5	1660.6	1665.7	1670.8	1675.9
41	1681.0	1686.1	1691.2	1696.4	1701.6	1706.7	1711.9	1717.1	1722.3	1727.4	1732.6	1737.9	1743.1	1748.3	1753.5	1758.8
42	1764.0	1769.3	1774.5	1779.8	1785.1	1790.4	1795.6	1800.9	1806.3	1811.6	1816.9	1822.2	1827.6	1832.9	1838.3	1843.6
43	1849.0	1854.4	1859.8	1865.2	1870.6	1876.0	1881.4	1886.8	1892.3	1897.7	1903.1	1908.6	1914.1	1919.5	1925.0	1930.5
44	1936.0	1941.5	1947.0	1952.5	1958.1	1963.6	1969.1	1974.7	1980.3	1985.8	1991.4	1997.0	2002.6	2008.2	2013.8	2019.4
45	2025.0	2030.6	2036.3	2041.9	2047.6	2053.2	2058.9	2064.6	2070.3	2075.9	2081.6	2087.3	2093.1	2098.8	2104.5	2110.3
46	2116.0	2121.8	2127.5	2133.3	2139.1	2144.8	2150.6	2156.4	2162.3	2168.1	2173.9	2179.7	2185.6	2191.4	2197.3	2203.1
47	2209.0	2214.9	2220.8	2226.7	2232.6	2238.5	2244.4	2250.3	2256.3	2262.2	2268.1	2274.1	2280.1	2286.0	2292.0	2298.0
48	2304.0	2310.0	2316.0	2322.0	2328.1	2334.1	2340.1	2346.2	2352.3	2358.3	2364.4	2370.5	2376.6	2382.7	2388.8	2394.9

I = Mom. Inertia = Σd^2.
S = Sec. Modulus = $I \div \frac{1}{2}h$.
M_r = Resist. Mom. = $(v \div \frac{1}{2}h_1)\Sigma d^2$.
v = Least value flange riv. thru web.
h_1 = Dist. bet. extreme flg. rivets.

TABLES OF SQUARES

FOR FIGURING MOMENTS OF INERTIA OF RIVET GROUPS
FOR VARIOUS RIVET SPACINGS

2½″ Spacing C. to C.

DISTANCE FROM NEUTRAL AXIS d		d^2	$2d^2$	$4d^2$	$6d^2$	$8d^2$	$10d^2$
1¼		2	3	6	9	12	16
	2½	6	13	25	38	50	63
3¾		14	28	56	84	112	141
	5	25	50	100	150	200	250
6¼		39	78	156	234	312	391
	7½	56	113	225	338	450	563
8¾		77	153	306	459	612	766
	10	100	200	400	600	800	1000
11¼		127	253	506	759	1012	1266
	12½	156	313	625	938	1250	1563
13¾		189	378	756	1134	1512	1891
	15	225	450	900	1350	1800	2250
16¼		264	528	1056	1584	2113	2641
	17½	306	613	1225	1838	2450	3063
18¾		352	703	1406	2109	2812	3516
	20	400	800	1600	2400	3200	4000
21¼		452	903	1806	2709	3613	4516
	22½	506	1013	2025	3038	4050	5063
23¾		564	1128	2256	3384	4512	5641
	25	625	1250	2500	3750	5000	6250
26¼		689	1378	2756	4134	5513	6891
	27½	756	1513	3025	4538	6050	7563
28¾		827	1653	3306	4959	6612	8266
	30	900	1800	3600	5400	7200	9000
31¼		977	1953	3906	5859	7813	9766
	32½	1056	2113	4225	6338	8450	10563
33¾		1139	2278	4556	6835	9113	11391
	35	1225	2450	4900	7350	9800	12250
36¼		1314	2628	5256	7885	10513	13141
	37½	1406	2813	5625	8438	11250	14063
38¾		1502	3003	6006	9010	12013	15016
	40	1600	3200	6400	9600	12800	16000

3″ Spacing C. to C.

DISTANCE FROM NEUTRAL AXIS d		d^2	$2d^2$	$4d^2$	$6d^2$	$8d^2$	$10d^2$
1½		2	5	9	14	18	23
	3	9	18	36	54	72	90
4½		20	41	81	122	162	203
	6	36	72	144	216	288	360
7½		56	113	225	338	450	563
	9	81	162	324	486	648	810
10½		110	221	441	662	882	1103
	12	144	288	576	864	1152	1440
13½		182	365	729	1094	1458	1823
	15	225	450	900	1350	1800	2250
16½		272	545	1089	1634	2178	2723
	18	324	648	1296	1944	2592	3240
19½		380	761	1521	2282	3042	3803
	21	441	882	1764	2646	3528	4410
22½		506	1013	2025	3038	4050	5063
	24	576	1152	2304	3456	4608	5760
25½		650	1301	2601	3902	5202	6503
	27	729	1458	2916	4374	5832	7290
28½		812	1625	3249	4874	6498	8123
	30	900	1800	3600	5400	7200	9000
31½		992	1985	3969	5954	7938	9923
	33	1089	2178	4356	6534	8712	10890
34½		1190	2381	4761	7142	9522	11903
	36	1296	2592	5184	7776	10368	12960
37½		1406	2813	5625	8438	11250	14063
	39	1521	3042	6084	9126	12168	15210
40½		1640	3281	6561	9842	13122	16403
	42	1764	3528	7056	10584	14112	17640
43½		1892	3785	7569	11354	15138	18923
	45	2025	4050	8100	12150	16200	20250
46½		2162	4325	8649	12974	17298	21623
	48	2304	4608	9216	13824	18432	23040

3½″ Spacing C. to C.

DISTANCE FROM NEUTRAL AXIS d		d^2	$2d^2$	$4d^2$	$6d^2$	$8d^2$	$10d^2$
1¾		3	6	12	18	24	31
	3½	12	25	49	74	98	123
5¼		28	55	110	165	220	276
	7	49	98	196	294	392	490
8¾		76	153	306	459	612	766
	10½	110	221	441	662	882	1103
12¼		150	300	600	900	1200	1501
	14	196	392	784	1176	1568	1960
15¾		248	496	992	1488	1985	2481
	17½	306	613	1225	1838	2450	3063
19¼		371	741	1482	2223	2964	3706
	21	441	882	1764	2646	3528	4411
22¾		518	1035	2070	3105	4141	5176
	24½	600	1201	2401	3602	4802	6003
26¼		689	1378	2756	4134	5513	6891
	28	784	1568	3136	4704	6272	7840
29¾		885	1770	3540	5310	7081	8851
	31½	992	1985	3969	5954	7938	9923
33¼		1106	2211	4422	6634	8845	11056
	35	1225	2450	4900	7350	9800	12250
36¾		1351	2701	5402	8104	10805	13506
	38½	1482	2965	5929	8894	11858	14823
40¼		1620	3240	6480	9721	12961	16201
	42	1764	3528	7056	10584	14112	17640
43¾		1914	3828	7656	11485	15313	19141
	45½	2070	4141	8281	12422	16562	20703
47¼		2233	4465	8930	13396	17861	22326
	49	2401	4802	9604	14406	19208	24010
50¾		2576	5151	10302	15454	20605	25756
	52½	2756	5513	11025	16538	22050	27563
54¼		2943	5886	11772	17659	23545	29431
	56	3136	6272	12544	18816	25088	31360

4″ Spacing C. to C.

DISTANCE FROM NEUTRAL AXIS d		d^2	$2d^2$	$4d^2$	$6d^2$	$8d^2$	$10d^2$
2		4	8	16	24	32	40
	4	16	32	64	96	128	160
6		36	72	144	216	288	360
	8	64	128	256	384	512	640
10		100	200	400	600	800	1000
	12	144	288	576	864	1152	1440
14		196	392	784	1176	1568	1960
	16	256	512	1024	1536	2048	2560
18		324	648	1296	1944	2592	3240
	20	400	800	1600	2400	3200	4000
22		484	968	1936	2904	3872	4840
	24	576	1152	2304	3456	4608	5760
26		676	1352	2704	4056	5408	6760
	28	784	1568	3136	4704	6272	7840
30		900	1800	3600	5400	7200	9000
	32	1024	2048	4096	6144	8192	10240
34		1156	2312	4624	6936	9248	11560
	36	1296	2592	5184	7776	10368	12960
38		1444	2888	5776	8664	11552	14440
	40	1600	3200	6400	9600	12800	16000
42		1764	3528	7056	10584	14112	17640
	44	1936	3872	7744	11616	15488	19360
46		2116	4232	8464	12696	16928	21160
	48	2304	4608	9216	13824	18432	23040
50		2500	5000	10000	15000	20000	25000
	52	2704	5408	10816	16224	21632	27040
54		2916	5832	11664	17496	23328	29160
	56	3136	6272	12544	18816	25088	31360
58		3364	6728	13456	20184	26912	33640
	60	3600	7200	14400	21600	28800	36000
62		3844	7688	15376	23064	30752	38440
	64	4096	8192	16384	24576	32768	40960

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RIVET GROUPS UNDER ECCENTRIC APPLICATION OF LOAD

When a group of rivets carries an eccentric load, as in Fig. 1, the several rivets in such a group are not equally stressed. Each carries an equal share ($r = P/2n$) of the vertical load P; and each carries in addition a force R due to moment, which is proportional to its distance a from the center of the rivet group and acts at right angles to the line connecting the rivet in question to the center of the group. The total stress on the rivet is the resultant of the two components defined above; it is greatest for the rivet which is on the side toward the load, and farthest from the center of the group.

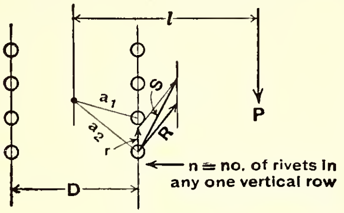


FIG. 1

Let a_1, a_2, etc., be the distances of respective rivets from center of group.

Let x = the unknown force due to moment on an imaginary rivet at unit distance from center of group.

Then, on any rivet at distance a, the force = ax, and its moment = a^2x.

Adding $(a_1)^2x + (a_2)^2x + \ldots$ etc., and equating to the moment Pl, solve for x.

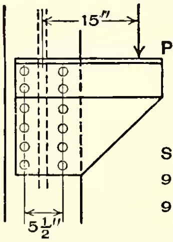
Then R (Fig. 1) = maximum ax, and S is found from R and r as shown in Fig. 1.

The group must be such in number and arrangement of rivets that S, the greatest stress on any rivet, does not exceed the value allowed by the Specification.

For any rivet group and any given lever arm of applied load a coefficient C may be found, such that C times the allowable value of one rivet equals the total load P permissible on the connection.

Thus $P = C \times S$.

Or, knowing P, and dividing by the allowable rivet value S, the necessary coefficient C is obtained, and a rivet group must be employed for which the coefficient is of that magnitude or greater.



$\frac{7}{8}$″ Rivets

$P = 25$ kips, $l = 15''$, $D = 5\frac{1}{2}''$

From Table II.,

If $n = 5$, $c = 2.3$

If $n = 6$, $c = 3.0$

$S = 9.02$ kips by Specification

$9.02 \times 2.3 = 20.7$ kips–Insufficient

$9.02 \times 3.0 = 27.1$ kips–Sufficient

FIG. 2

General expressions for the coefficient C are very complex, and for all except simple, symmetrical cases the joint must be detailed by a cut-and-try process based on the foregoing principles and without deriving of coefficients. For the simplest cases occurring repeatedly in practice, the coefficients C are given in the Tables on page 199; in connection with Fig. 2 is given an example of the use thereof.

In the case of eccentric brackets of the type shown in Fig. 3, in which the moment produces tension on the rivets, there is no exact knowledge as to the location of the neutral axis; it probably lies somewhere below the center line of the connection. Nor is there exact knowledge of the permissible combination of tension with vertical shear on the uppermost rivets. A safe and accepted method of design for brackets of the type shown is to consider the rivets to be under an eccentric loading similar to that exemplified in Table I, page 199. The coefficient C for such cases will be twice the values tabulated in Table I to conform with the two vertical rows of rivets; the resultant stress on one extreme rivet not to exceed the A. I. S. C. Specification allowance of 15.0 kips per square inch.

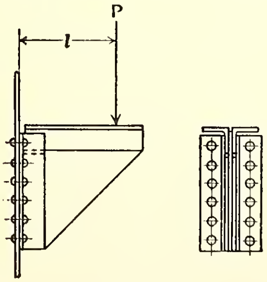


FIG. 3

Example:

$P = 22$ kips $l = 12''$ ¾″ rivets, 3″ pitch.
Allowable stress on one rivet $= 15.0 \times .4418 = 6.63$ kips.

$$C = \frac{P}{2 \times S} = \frac{22}{2 \times 6.63} = 1.66$$

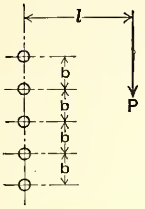
From Table I for $l = 12''$ six rivets are required in each of two vertical rows.

The thickness of the bracket connection angles should be ample to resist the bending moment.

RIVET GROUPS UNDER ECCENTRIC APPLICATION OF LOAD

Nomenclature:
n = total number of rivets in any one vertical row.
P = permissible load, acting with lever arm l.
S = permissible load on one rivet by Specification.
C = coefficient as tabulated below.
P = C × S; or, knowing P, required minimum C = $\frac{P}{S}$

Case I

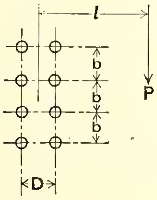


In Table, b = 3″

n \ l	1″	2″	3″	6″	9″	12″	15″	18″	21″	24″
2	1.7	1.2	.89	.49	.33	.25	.20	.17	.14	.12
3	2.7	2.1	1.7	.95	.65	.49	.40	.33	.28	.25
4	3.7	3.1	2.6	1.5	1.1	.82	.66	.55	.47	.41
5	4.7	4.2	3.5	2.2	1.6	1.2	.98	.82	.71	.62
6	5.8	5.2	4.6	3.0	2.2	1.7	1.4	1.1	.99	.87
7	6.8	6.3	5.6	3.9	2.8	2.2	1.8	1.5	1.3	1.2
8	7.8	7.3	6.7	4.8	3.6	2.8	2.3	1.9	1.7	1.5
9	8.8	8.4	7.7	5.8	4.4	3.5	2.8	2.4	2.1	1.8
10	9.8	9.4	8.8	6.8	5.2	4.2	3.4	2.9	2.5	2.2
11	10.9	10.4	9.8	7.8	6.1	4.9	4.1	3.5	3.0	2.7
12	11.9	11.5	10.9	8.8	7.0	5.7	4.8	4.1	3.5	3.1

In general, $C = \dfrac{n}{\sqrt{\left[\dfrac{6\,l}{(n+1)\,b}\right]^2 + 1}}$

Case II

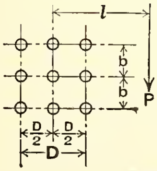


In Table, b = 3″ and D = 5½″ or 9½″

l	1″		2″		3″		6″		9″		12″		15″		18″		21″		24″	
n \ D	5½	9½	5½	9½	5½	9½	5½	9½	5½	9½	5½	9½	5½	9½	5½	9½	5½	9½	5½	9½
2	3.1	3.4	2.5	2.9	2.1	2.5	1.4	1.8	1.1	1.4	0.8	1.2	0.7	1.0	0.6	0.9	0.5	0.8	0.5	0.7
3	4.9	5.1	4.1	4.4	3.4	3.9	2.3	2.9	1.7	2.2	1.4	1.8	1.1	1.6	1.0	1.4	0.9	1.2	0.8	1.1
4	6.8	7.0	5.8	6.1	5.0	5.4	3.4	4.0	2.5	3.1	2.0	2.6	1.7	2.2	1.4	1.9	1.2	1.7	1.1	1.5
5	8.8	8.9	7.7	7.9	6.7	7.0	4.6	5.2	3.5	4.1	2.8	3.3	2.3	2.8	1.9	2.4	1.7	2.1	1.5	1.9
6	10.9	10.8	9.6	9.7	8.5	8.7	6.0	6.5	4.5	5.1	3.6	4.2	3.0	3.6	2.6	3.1	2.2	2.7	2.0	2.4
7	12.9	12.8	11.7	11.6	10.4	10.6	7.5	8.0	5.8	6.3	4.6	5.2	3.8	4.4	3.3	3.8	2.8	3.3	2.5	3.0
8	15.0	14.8	13.7	13.6	12.4	12.4	9.2	9.6	7.1	7.6	5.7	6.2	4.8	5.3	4.1	4.6	3.5	4.0	3.1	3.6
9	17.0	16.9	15.8	15.6	14.5	14.4	11.0	11.2	8.6	9.0	6.9	7.4	5.8	6.3	4.9	5.4	4.3	4.8	3.8	4.3
10	19.1	18.9	17.9	17.7	16.6	16.4	12.8	13.0	10.1	10.5	8.2	8.7	6.9	7.4	5.9	6.4	5.2	5.6	4.6	5.0
11	21.2	20.9	20.0	19.7	18.7	18.4	14.8	14.8	11.8	12.1	9.7	10.0	8.1	8.5	7.0	7.4	6.1	6.5	5.4	5.8
12	23.2	23.0	22.1	21.8	20.8	20.5	16.8	16.7	13.5	13.7	11.2	11.4	9.4	9.8	8.1	8.5	7.1	7.5	6.3	6.7

In general, $C = \dfrac{n}{\sqrt{\left[\dfrac{l(n-1)b}{D^2 + \frac{1}{3}(n^2-1)b^2}\right]^2 + \left[\dfrac{l\,D}{D^2 + \frac{1}{3}(n^2-1)b^2} + \frac{1}{2}\right]^2}}$

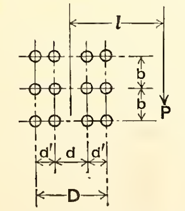
Case III



Case III, not tabulated.

In general, $C = \dfrac{n}{\sqrt{\left[\dfrac{l(n-1)b}{D^2 + \frac{1}{2}(n^2-1)b^2}\right]^2 + \left[\dfrac{l\,D}{D^2 + \frac{1}{2}(n^2-1)b^2} + \frac{1}{3}\right]^2}}$

Case IV



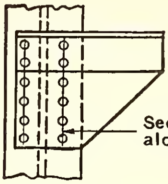
In Table, b = 3″
d′ = 2½″ d′ = 3″
d = 4½″ d = 5½″
d′ = 2½″ d′ = 3″
D = 9½″ D = 11½″

l	1″		2″		3″		6″		9″		12″		15″		18″		21″		24″	
n \ D	9½	11½	9½	11½	9½	11½	9½	11½	9½	11½	9½	11½	9½	11½	9½	11½	9½	11½	9½	11½
2	6.2	6.4	5.0	5.3	4.2	4.5	2.8	3.1	2.1	2.4	1.7	1.9	1.4	1.6	1.2	1.4	1.1	1.2	1.0	1.1
3	9.6	9.8	8.0	8.2	6.7	7.1	4.6	5.0	3.5	3.8	2.8	3.1	2.3	2.6	2.0	2.2	1.8	2.0	1.6	1.8
4	13.3	13.4	11.2	11.5	9.7	10.0	6.7	7.1	5.1	5.4	4.1	4.4	3.4	3.7	2.9	3.2	2.6	2.8	2.3	2.5
5	17.2	17.2	14.8	15.0	12.9	13.1	9.1	9.4	6.9	7.3	5.6	5.9	4.7	5.0	4.0	4.3	3.5	3.8	3.1	3.4
6	21.2	21.1	18.6	18.6	16.4	16.5	11.7	12.1	9.0	9.4	7.3	7.6	6.1	6.4	5.2	5.5	4.6	4.9	4.1	4.3
7	25.2	25.1	22.5	22.5	20.1	20.1	14.7	14.9	11.3	11.7	9.2	9.5	7.7	8.0	6.6	6.9	5.8	6.1	5.1	5.4
8	29.3	29.2	26.5	26.4	23.9	23.9	17.8	18.0	13.9	14.2	11.3	11.6	9.5	9.8	8.2	8.5	7.2	7.5	6.4	6.6
9	33.4	33.3	30.6	30.5	27.9	27.8	21.2	21.3	16.7	16.9	13.7	13.9	11.5	11.8	9.9	10.2	8.7	9.0	7.7	8.0
10	37.6	37.4	34.8	34.6	32.0	31.8	24.8	24.8	19.7	19.9	16.2	16.4	13.7	13.9	11.8	12.1	10.4	10.6	9.2	9.5
11	41.7	41.5	39.0	38.7	36.2	35.9	28.5	28.5	22.9	23.0	18.9	19.1	16.0	16.2	13.9	14.1	12.2	12.4	10.9	11.1
12	45.8	45.6	43.2	42.8	40.3	40.0	32.4	32.2	26.3	26.3	21.8	21.9	18.5	18.7	16.0	16.3	14.1	14.4	12.6	12.8

In general, $C = \dfrac{n}{\sqrt{\left[\dfrac{l(n-1)b}{d^2 + D^2 + \frac{2}{3}(n^2-1)b^2}\right]^2 + \left[\dfrac{l\,D}{d^2 + D^2 + \frac{2}{3}(n^2-1)b^2} + \frac{1}{4}\right]^2}}$

NET SECTION MODULI OF PLATES

Diameter of holes assumed ⅛″ larger than nominal diameter of rivet



Rivets spaced 3″ vertically

No. of Rivets in One Vertical Line	Depth of Plate in Inches	¾″ RIVETS					⅞″ RIVETS					1″ RIVETS				
		Thickness of Plate, In.					Thickness of Plate, In.					Thickness of Plate, In.				
		¼	⅜	½	⅝	¾	⅜	½	⅝	¾	⅞	½	⅝	¾	⅞	1
2	6	1.2	1.8	2.3	2.9	3.5	1.7	2.3	2.9	3.4	4.0	2.2	2.7	3.2	3.8	4.3
3	9	2.5	3.8	5.0	6.3	7.5	3.6	4.8	5.9	7.1	8.3	4.5	5.6	6.8	7.9	9.0
4	12	4.4	6.3	8.7	11	13	6.2	8.2	10	12	14	7.8	9.7	12	14	16
5	15	6.8	10	14	17	20	10	13	16	19	22	12	15	18	21	24
6	18	9.6	15	19	24	29	14	18	23	27	32	17	21	26	30	34
7	21	13	20	26	33	39	19	25	31	37	43	23	29	35	41	47
8	24	17	26	34	43	51	24	32	40	48	56	30	38	45	53	61
9	27	22	32	43	54	65	31	41	51	61	71	38	48	57	67	77
10	30	27	40	53	67	80	38	50	63	75	88	47	59	71	83	94
12	36	38	58	77	96	115	54	72	90	108	126	68	85	102	119	136
14	42	52	78	104	130	157	74	98	123	147	172	92	115	138	161	184
16	48	68	102	136	170	204	96	128	160	192	224	120	150	180	211	241
18	54	86	129	172	215	259	122	162	203	243	284	152	190	228	266	304
20	60	106	160	213	266	319	150	200	250	300	350	188	235	282	329	376
22	66	129	193	257	322	386	182	242	303	363	424	227	284	341	398	454
24	72	153	230	306	383	459	216	288	360	432	504	270	338	406	473	541
26	78	180	270	359	449	539	254	338	423	507	592	317	397	476	555	634
28	84	208	313	417	521	625	294	392	490	588	686	368	460	552	644	736
30	90	240	359	478	598	718	338	450	563	675	788	422	528	633	739	845
32	96	272	408	544	680	816	384	512	640	768	896	480	600	721	841	961
34	102	308	461	614	768	922	434	578	723	867	1012	542	678	813	949	1085
36	108	344	517	689	861	1033	486	648	810	972	1134	608	760	912	1064	1216

Interpolate for intermediate thicknesses of plates.

DESIGN OF STEEL PURLINS

FOR SLOPING ROOFS

CONDITIONS OF DESIGN.

Type I. With the purlin web placed normal to the slope of the roof, with a rigid covering such as wood sheathing on common rafters, or 2″ wood sheathing, the loads may be resolved into components parallel and normal to the roof. The component parallel to the roof is assumed as carried by the roof covering, and the normal component by the purlin. The purlin is therefore free to bend only in a plane normal to the roof.

Type II. With the purlin web placed normal to the slope of the roof, and with a non-rigid covering such as corrugated steel or metal roof deck, the purlin is assumed as free to bend about an axis at right angles to the direction of the resultant loads.

Type III. With the purlin web placed in a vertical plane, and with either a rigid or non-rigid roof covering, the purlin is assumed as free to bend about an axis at right angles to the direction of the resultant loads.

Type IV. With the purlin web placed normal to the slope of the roof, with either a rigid or non-rigid roof covering, and with lateral support consisting of one or more tie-rods parallel to the plane of the roof, it is assumed that the span (L) for load components normal to the roof is equal to the distance between purlin supports, and that the span (L_1) for load components parallel to the roof is equal to the distance between tie-rods, or between tie-rod and purlin support. The purlin is assumed free to bend in any direction at the various points of maximum combined moments.

GENERAL ASSUMPTIONS FOR ALL EXAMPLES.

Slope of roof = 30° with the horizontal; purlins spaced 6′-0″ centers; span of purlin (L) = 16′-0″; dead load ($D.L.$) = 13.0 lbs. per sq. ft. of roof, for rigid covering, and 8.0 lbs. for non-rigid covering; snow load ($S.L.$) = 15.0 lbs per sq. ft. of roof; and normal wind load ($W.L.$) = 24.0 lbs. per sq. ft. of roof. Loading combinations are,

Case 1, *D.L.* and *S.L.* Case 2, *D.L.* and *W.L.* Case 3, *D.L.* plus *W.L* plus ½*S.L.*

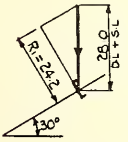
Allowable fiber stress is 18,000 lbs. per sq. in. in structural steel.

Depth of purlin sections to be not less than 0.0375 span, or $0.0375 \times 16 \times 12 = 7.2$ in.

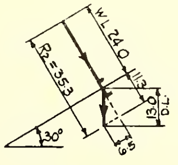
The letter "S", with or without subscripts, denotes Section Modulus, and "R" = resultant loads in lbs. per sq. ft.

Example: Type I.

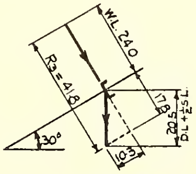
$D.L. = 13.0\#$. $W.L. = 24.0\#$. $S.L. = 15.0\#$. All applied and resultant loads are in lbs. sq. ft of roof surface.



Case 1



Case 2



Case 3

$$S = \frac{R \times 6.0 \times 16.0^2 \times 12}{8 \times 18{,}000} = 0.128\,R \text{ in.}^3$$

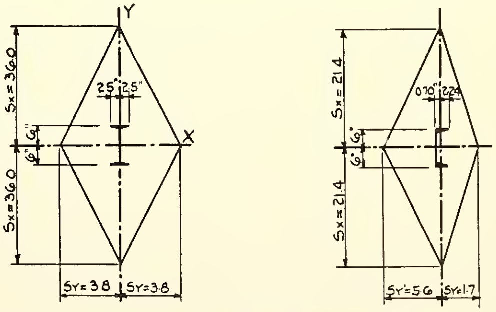
$S_1 = 0.128 \times 24.2 = 3.10$ in.^{3}—Case 1.
$S_2 = 0.128 \times 35.3 = 4.52$ in.^{3}—Case 2.
$S_3 = 0.128 \times 41.8 = 5.35$ in.^{3}—Case 3.

The value of "S" as computed for each case is the required section modulus about the principal axis, x-x.

Use 7″ @ 9.8# ⊏, having section modulus of 6.0 about axis x-x.

The S-Polygon.

In applying the graphical method of design to I-beam and channel purlins, loaded as in Types II, III and IV, involving unsymmetrical bending, it is to be noted that the co-ordinates of the apices of the "S" polygon are equal in value to the Section Modulii, S_X and S_Y, of that section, as listed in the structural steel handbooks. These co-ordinates can therefore be plotted directly in their proper positions on the principal axes of the sections, and the "S" lines, connecting the points plotted, can be drawn for all four quadrants.



TYPICAL EXAMPLES OF S-POLYGONS

$S_X = I_X/c = 215.8/6 = 36.0$ in.^{3}
$S_Y = I_Y/c = 9.5/2.5 = 3.8$ in.^{3}

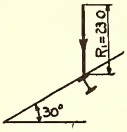
12″ @ 31.8# I

$S_X = I_X/c = 128.1/6 = 21.4$ in.^{3}
$S_Y = I_Y/c = 3.9/2.24 = 1.7$ in.^{3}
$S_Y' = I_Y/c = 3.9/0.70 = 5.6$ in.^{3}

12″ @ 20.7# ⊏

Example: Type II.

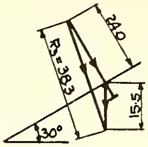
Total dead load in lbs. per sq. ft. of roof surface: Roofing = 3.0#; Metal deck = 2.0#; purlins = 3.0#. Total 18.0#.



Case 1

D.L.+S.L.

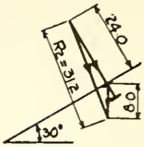
$$S_1=\frac{23.0\times6\times16^2\times12}{8\times18{,}000}=2.94$$



Case 2

D.L.+W.L.

$$S_2=\frac{31.2\times6\times16^2\times12}{8\times18{,}000}=3.99$$



Case 3

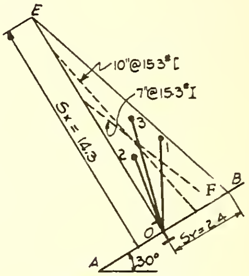
D.L.+W.L.+½S.L.

$$S_3=\frac{38.3\times6\times16^2\times12}{8\times18{,}000}=4.90$$

The "S" computed for each case is the section modulus required about an axis at right angles to the resultant load, "*R*".

Construction of "S" Polygon:

Construct line *AB* to the slope of roof; from any point, "*O*" on *AB* draw O-1, O-2 and O-3, parallel respectively to R_1, R_2, and R_3, and equal to S_1, S_2, and S_3. Assuming an 8″ @17# Standard Mill Section (*B39N*), the value of $S_x = 14.3$ in.³, and the value of $S_Y = 2.4$ in.³. From point "*O*" draw *OE* and *OF* to scale, parallel to the principal axes of the purlin section and equal respectively to S_x and S_Y. The "*S*" line *EF* passes above any of the points 1, 2, or 3, which indicates that the section modulus of the assumed section about an axis at right angles to the direction of the resultant load on the purlin is greater than that required for any of the three conditions of loading.

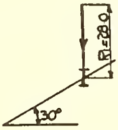


S-POLYGON

The "*S*" polygon for a 10″ @ 15.3# channel and a 7″ @ 15.3# I-beam are shown in dotted lines. In both cases the "*S*" line, *EF*, passes below the points 1 and 3, which indicates that the section modulus of each of these sections is less than that required for Cases 1 and 3.

Example: Type III.

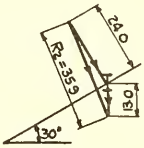
Total dead load (rigid roof covering) lbs. sq. ft.: Roofing = 3.0#; 2″ sheathing = 7.0#; purlins = 3.0#. Total 13.0#.



Case 1

D.L+S.L.

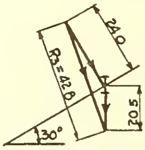
$$S_1=\frac{28.0\times6.0\times16^2\times12}{8\times18{,}000}=3.58$$



Case 2

D.L.+W.L.

$$S_2=\frac{35.9\times6.0\times16^2\times12}{8\times18{,}000}=4.60$$



Case 3

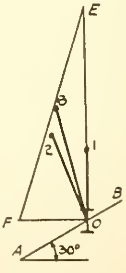
D.L.+W.L.+½S.L.

$$S_3=\frac{42.8\times6.0\times16^2\times12}{8\times18{,}000}=5.48$$

The "*S*" value as computed for each case is the section modulus required about an axis at right angles to resultant load, "*R*".

Construction of "S" Polygon:

Draw line *AB* to the slope of the roof, and from any point, "*O*", on *AB*, draw O-1, O-2, and O-3, respectively, parallel to R_1, R_2 and R_3 and equal to S_1, S_2, and S_3. Assuming an 8″ @ 17# Standard Mill Section (*B39N*), the value of $S_x = 14.3$ in.³, and $S_Y = 2.4$ in.³. From point "*O*" draw *OE* and *OF*, parallel to the principal axes of the section and equal respectively to S_x and S_Y. The "*S*" line *EF* passes through or above any of the points 1, 2, or 3, and the assumed section is therefore adequate.



S-POLYGON

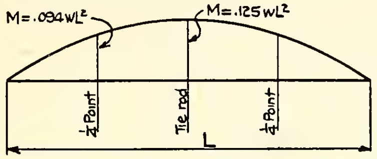
PURLINS LATERALLY SUPPORTED BY TIE RODS.

One line of tie rods at the center of the purlin is usually sufficient. The tie rods should extend over the ridge, forming a continuous line; in case the purlins are so arranged that this is impossible, the upper ties should run diagonally to the roof trusses.

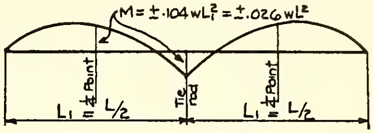
Tie rods may be omitted where the roof slope is less than 20° with the horizontal.

ASSUMED MOMENT CO-EFFICIENTS.

(*a*) One Tie Rod:

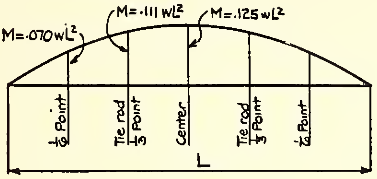

M=.094wL²
M=.125wL²
¼ Point
Tie rod
¼ Point
L

Perpendicular to Roof

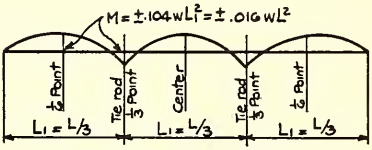

M=±.104wL₁²=±.026wL²
L₁ = ¼ Point = L/2
Tie rod
L₁ = ¼ Point = L/2

Parallel to Roof

(*b*) Two Tie Rods:


M=.070wL²
M=.111wL²
M=.125wL²
⅙ Point
Tie rod ⅓ Point
Center
Tie rod ⅓ Point
⅙ Point
L

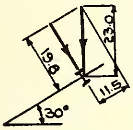
Perpendicular to Roof


M=±.104wL₁²=±.016wL²
⅙ Point
Tie rod ⅓ Point
Center
Tie rod ⅓ Point
⅙ Point
L₁=L/3
L₁=L/3
L₁=L/3

Parallel to Roof

Example: Type IV.

In using the "*S*" polygon method of design it is necessary to determine the resultant moment of the tie rod and at a point half way between the tie rod and the truss. These resultants are equal to the vector sum of the component moments perpendicular and parallel to the roof, and the required section modulii are determined from these resultant moments.


19.8
23.0
11.5
30°

Case 1

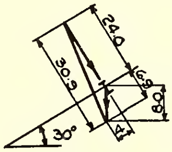
D.L and *S.L*

$$S_P = \frac{.026\times11.5\times6\times16^2\times12}{18,000} = +0.31 \text{ @ ¼ pts.}$$

$$S_P = -0.31 \text{ @ Tie rod}$$

$$S_N = \frac{.094\times19.8\times6\times16^2\times12}{18,000} = +1.91 \text{ @ ¼ pts.}$$

$$S_N = \frac{.125\times19.8\times6\times16^2\times12}{18,000} = +2.54 \text{ @ Tie rod}$$


24.0
30.9
6.9
8.0
30°

Case 2

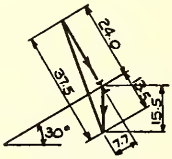
D.L and W.L.

$$S_P = \frac{.026\times4\times6\times16^2\times12}{18,000} = +0.11 \text{ @ ¼ pts.}$$

$$S_P = -0.11 \text{ @ Tie rod}$$

$$S_N = \frac{.094\times30.9\times6\times16^2\times12}{18,000} = +2.97 \text{ @ ¼ pts.}$$

$$S_N = \frac{.125\times30.9\times6\times16^2\times12}{18,000} = +3.95 \text{ @ Tie rod}$$


24.0
37.5
13.5
15.5
7.7
30°

Case 3

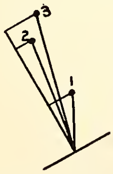
D.L. and *W.L.* and ½*S.L.*

$$S_P = \frac{.026\times7.7\times6\times16^2\times12}{18,000} = +0.20 \text{ @ ¼ pts.}$$

$$S_P = -0.20 \text{ @ Tie rod}$$

$$S_N = \frac{.094\times37.5\times6\times16^2\times12}{18,000} = +3.60 \text{ @ ¼ pts.}$$

$$S_N = \frac{.125\times37.5\times6\times16^2\times12}{18,000} = +4.80 \text{ @ Tie rod}$$

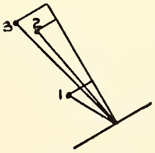


Resultant "*S*" @ ¼ Points

$S_1 = 1.93$ in.³

$S_2 = 2.98$ in.³

$S_3 = 3.61$ in.³



Resultant "*S*" @ Tie Rod

$TS_1 = 2.56$ in.³

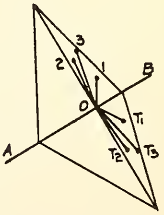
$TS_2 = 3.96$ in.³

$TS_3 = 4.81$ in.³

Note: At tie rod, the section modulii for component parallel to roof, is negative, and plotted to left of origin.

Construction of "S" Polygon:

Assume 8″ @ 11.5#[, with $S_X = 8.1$ and $S_Y = 0.79$. Construct "*S*" polygon for the assumed section and draw 0-1, 0-2, and 0-3 above *AB*, equal respectively to S_1, S_2 and S_3. Draw $O\text{-}T_1$, $O\text{-}T_2$ and $O\text{-}T_3$ below *AB*, equal and parallel to TS_1, TS_2 and TS_3. All of the points 1, 2, 3, T_1, T_2 and T_3 fall within the "*S*" line of the polygon, and the assumed section is therefore adequate.


3
2
1
B
O
T₁
T₂
T₃
A

"S" Polygon

WIND STRESSES

GENERAL.

Exceptionally tall buildings, towers, and similar unusually important structures may quite properly be designed by one of the so-called exact methods of wind analysis, such as the theory of least work, the slope deflection, or the moment distribution method. For the ordinary structure encountered by the average engineer with limited time at his disposal, one of the approximate methods will prove more suitable and will, indeed, assure a satisfactory solution of the problem. If desired, the accuracy of the wind design may be checked by one of the exact methods.

The two most commonly used of the approximate methods are usually distinguished as the Cantilever and Portal systems of analysis. Both have been used satisfactorily on hundreds of buildings. In the Cantilever method, it is assumed that the column unit stresses vary as the distances from the center of gravity of the bent; as a result, shears and moments vary in columns and girders. In the Portal method, however, it is assumed that the shears and moments in exterior columns are half the corresponding values for interior columns and that girder shears and moments are therefore uniform in all spans of a bent. Although the Cantilever method may be theoretically more exact, the simplicity of calculations and the uniformity of joint stresses found by the Portal method have perhaps occasioned its wider use. It will be used herein.

The following assumptions are made:

1. A bent of a frame acts as a series of independent portals.
2. The point of contraflexure of columns is at midheight.
3. The point of contraflexure of girders is at midspan.
4. The horizontal shear on any plane is divided equally between panels of a bent.
5. An exterior column takes half the shear value of an interior column.
6. The panel length does not affect the girder bending moments.
7. The direct stress from wind is taken by the exterior columns.
8. The building frame alone resists the entire wind.

FORMULAE:

The total shear acting on a given story is the sum of the wind loads above, $V\Sigma = \Sigma W$.

The shear distribution is $\dfrac{V\Sigma}{n}$ for interior columns, and $\dfrac{V\Sigma}{2n}$ for exterior columns.

Bending moment in interior columns $= M_i = \dfrac{V\Sigma h}{2n}$; for exterior columns $=$

$$M_e = \frac{V\Sigma h}{4n} = \frac{M_i}{2}$$

Bending moment in girder connection $= M_G = \dfrac{M_{ia} + M_{ib}}{2} = \dfrac{M_{ea} + M_{eb}}{4}$

Direct stress due to wind is zero in interior columns of a bent of equal panels; it may ordinarily be disregarded under any condition. In exterior columns it is tension in windward and compression in leeward columns, and is

$$C = T = \Sigma\left[W_a \times \frac{h_a}{2} + W_b\left(\frac{h_a}{2} + h_b\right) + W_c\left(\frac{h_a}{2} + h_b + h_c\right) + \dots\right] \div L.$$

The direct compression in girders, usually negligible, is the algebraic sum of the wind panel load and the difference of the shears in column above and below floor in question, to windward side of girder considered, or

$$G_c = W - \Sigma\,(V_a - V_b)$$

NOMENCLATURE:

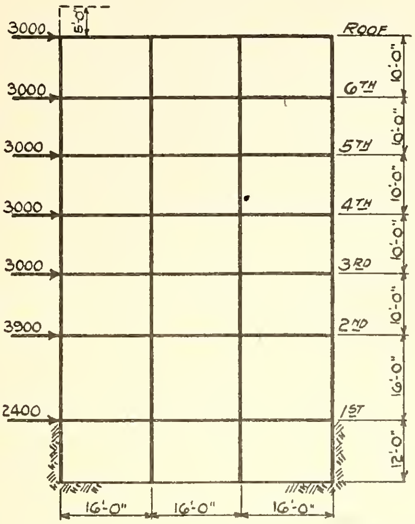
In the above, subscripts *a*, *b*, etc., refer to adjacent stories.

h = Story height.
L = Width of bent.
n = Number of panels in bent.
$V\Sigma$ = Total shear acting on given plane.
W = Wind load.

DESIGN OF TYPICAL BENT:

Compute wind stresses for a three panel, 6 story bent as shown; exposure (spacing) of bents being 20′-0″. Assume 5′-0″ parapet wall. Wind 15#□′. Assume basement moment arm as story height.

DIAGRAM OF BENT



COMPUTATIONS

	WIND LOADS	TOTAL SHEAR	COLUMN BEND'G MOM.			GIRDER MOM.		DIRECT STRESS EXT. COL.
			TOTAL	EACH INTERIOR	EACH EXTERIOR	TOTAL	EACH CONN.	
R	3000					15000	2500	
		3000	15000	5000	2500			
6	3000					45000	7500	310
		6000	30000	10000	5000			
5	3000					75000	12500	1250
		9000	45000	15000	7500			
4	3000					105000	17500	2810
		12000	60000	20000	10000			
3	3000					135000	22500	5000
		15000	75000	25000	12500			
2	3900					226200	37750	7820
		18900	151200	50400	25200			
1	2400					406800	67750	12500
		21300	255600	85200	42600			
B								18400

It will be noted from the above that the use of this method is very simple, requiring no explanation. For all practical purposes it is perfectly satisfactory for the average structure.

We know all too little about the action of wind on buildings; certainly not enough to warrant too much refinement in design. For example, we entirely disregard the stiffening effect of floors, walls and heavy partitions, yet they undoubtedly add much to the rigidity of structures.

This question of rigidity is very important in the analysis of slender buildings with a large height ratio. Stiffness is then the prime requisite, and the design should bear this in mind.

Many reference works contain authoritative data on wind design. Robins Fleming's "Wind Stresses in Buildings", published by John Wiley and Sons, and "Wind Bracing", by Henry V. Spurr, a McGraw-Hill publication, are most highly recommended.

Tall or unusual structures should receive careful treatment; if designed by one of the approximate methods they may well be checked by slope deflection or moment distribution. In such buildings the relative stiffness and deflection of columns should be analyzed.

WIND BRACING DETAILS:

A steel girder cannot be assumed as simply supported for static loads and, at the same time, be fixed at the ends for wind moments. If moment connections are used for wind the beam certainly cannot be considered as simply supported for live and dead loads as any degree of end fixity is certain to develop end moments, of amount depending upon the degree of fixation, from static loads, and the connection may be greatly over-stressed under such conditions.

Where possible to use it, diagonal bracing is the most efficient and economical type of wind bracing. K-Frames, knee braces, brackets and gussets may be used to advantage where architectural details permit; when not possible to use these types because of clearance and finish requirements, the so-called "Hitch" connection or split beam, and, for smaller moments, the clip angle connection, must be used at a sacrifice of stiffness and efficiency. All these types of connections are described in detail in other books; the designer must employ his ingenuity in utilizing the best type of joint to meet the conditions.

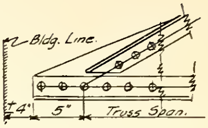
The question of wind connections, like that of the entire theory of wind design, is receiving a great deal of attention and study, and it is hoped that the necessary additional research and investigation will be made.

Truss span given in second column of table is distance c. to c. working points, and is 1'-6" ± less than width of bldg.

DIMENSIONS OF BOWSTRING TRUSSES

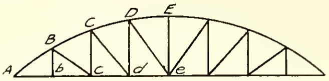
CIRCULAR ARC DESIGN

HEIGHT = ⅛ SPAN



8 PANEL

Bevel A = 6⅜ to 12
B = 4½ to 12
C = 2⅞ to 12
D = 1 7/16 to 12

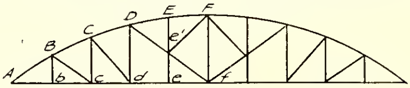


Bevel B-c = 5 7/16 to 12
C-d = 9⅛ to 12
D-e = 11 5/16 to 12

Bldg. Width	Truss Span	Panel Length	Radius	Vertical Members B-b	C-c	D-d	E-e	Diagonal Members B-c	C-d	D-e	Lengths of Arcs Whole Arc	A-B	B-C	C-D	D-E
40-0	38-6	4-9¾	40-10⅞	2-2 3/16	3-8	4-6 5/16	4-9¾	5-3 7/16	6-0⅝	6-7¼	40-1	5-3⅜	5-0½	4-10¾	4-9⅞
41-0	39-6	4-11¼	41-11⅝	2-2 15/16	3-9⅛	4-7¾	4-11¼	5-5 1/16	6-2½	6-9⅜	41-1½	5-5⅛	5-2	5-0¼	4-11⅜
42-0	40-6	5-0¾	43-0⅜	2-3½	3-10¼	4-9 1/16	5-0¾	5-6 11/16	6-4⅜	6-11 7/16	42-2	5-6¾	5-3⅝	5-1¾	5-0⅞
43-0	41-6	5-2¼	44-1⅛	2-4¼	3-11⅜	4-10 9/16	5-2¼	5-8⅜	6-6¼	7-1½	43-2½	5-8⅜	5-5 3/16	5-3 5/16	5-2½
44-0	42-6	5-3¾	45-1⅞	2-4⅞	4-0 9/16	5-0	5-3¾	5-10 1/16	6-8⅛	7-3 9/16	44-3	5-10 1/16	5-6¾	5-4 13/16	5-3⅞
45-0	43-6	5-5¼	46-2⅝	2-5 9/16	4-1 11/16	5-1⅜	5-5¼	5-11⅝	6-10	7-5 9/16	45-3½	5-11 11/16	5-8⅜	5-6 5/16	5-5⅜
46-0	44-6	5-6¾	47-3⅜	2-6¼	4-2 13/16	5-2 13/16	5-6¾	6-1 5/16	6-11⅞	7-7 11/16	46-4	6-1 5/16	5-9 13/16	5-7⅞	5-6⅞
47-0	45-6	5-8¼	48-4⅛	2-6 15/16	4-3 15/16	5-4¼	5-8¼	6-2 13/16	7-1¾	7-9¾	47-4½	6-2 13/16	5-11½	5-9⅜	5-8 [illegible]
48-0	46-6	5-9¾	49-4⅞	2-7⅝	4-5⅛	5-5⅝	5-9¾	6-4 9/16	7-3 11/16	7-11¾	48-5	6-4⅝	6-1 1/16	5-10⅞	5-9 [illegible]
49-0	47-6	5-11¼	50-5⅝	2-8¼	4-6¼	5-7 1/16	5-11¼	6-6 3/16	7-5 9/16	8-1⅞	49-5½	6-6¼	6-2⅝	6-0 7/16	5-11 [illegible]

10 PANEL

Bevel A = 6⅜ to 12
B = 4⅞ to 12
C = 3 9/16 to 12
D = 2 5/16 to 12
E = 1⅛ to 12

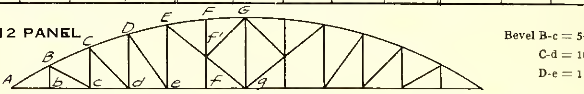


Bevel B-c = 5⅝ to 12
C-d = 9 13/16 to 12
D-e' = 6⅜ to 12
e'-f = 6⅜ to 12
e'-F = 8⅝ to 12

Bldg Width	Truss Span	Panel Length	Radius	Vertical Members B-b	C-c	D-d	E-e'	e'-e	F-f	Diagonal Members B-c	C-d	D-e'	e'-f	e'-F	Lengths of Arcs Whole Arc	A-B	B-C	C-D	D-E	E-F
50-0	48-6½	4-10¼	51-6⅞	2-3¼	3-11⅝	5-1 13/16	3-3 3/16	2-6 15/16	6-0 13/16	5-4 5/16	6-3¼	5-5 15/16	5-5 15/16	5-11 11/16	50-6½	5-4 5/16	5-1¾	4-11 13/16	4-10⅞	4-10⅜
51-0	49-5¾	4-11⅜	52-6⅞	2-3 13/16	4-0 9/16	5-2 15/16	3-3 15/16	2-7½	6-2¼	5-5 9/16	6-4 11/16	5-7 3/16	5-7 3/16	6-1 3/16	51-6¼	5-5 9/16	5-2 15/16	5-1⅛	5-0	4-11½
52-0	50-5	5-0½	53-6 13/16	2-4⅜	4-1½	5-4⅛	3-4¾	2-8 1/16	6-3⅝	5-6 13/16	6-6 3/16	5-8 7/16	5-8 7/16	6-2 9/16	52-5⅞	5-6 13/16	5-4 3/16	5-2¼	5-1⅛	5-0 9/16
53-0	51-5½	5-1¾	54-8⅛	2-4 13/16	4-2½	5-5½	3-5 9/16	2-8¾	6-5 3/16	5-8 3/16	6-7¾	5-9⅞	5-9⅞	6-4 1/16	53-6⅞	5-8 3/16	5-5 7/16	5-3 9/16	5-2⅜	5-1⅞
54-0	52-6	5-3	55-9⅜	2-5½	4-3½	5-6 13/16	3-6 7/16	2-9 7/16	6-6¾	5-9 9/16	6-9⅜	5-11 5/16	5-11 5/16	6-5⅝	54-7⅞	5-9⅝	5-6¾	5-4 13/16	5-3 11/16	5-3 1/16
55-0	53-6½	5-4¼	56-10⅝	2-6 1/16	4-4½	5-8 1/16	3-7¼	2-10	6-8 5/16	5-10 15/16	6-11	6-0 11/16	6-0 11/16	6-7 3/16	55-9	5-11	5-8⅛	5-6⅛	5-4 15/16	5-4 5/16
56-0	54-5¾	5-5⅜	57-10⅝	2-6⅝	4-5½	5-9 5/16	3-7 15/16	2-10 11/16	6-9¾	6-0 3/16	7-0½	6-2	6-2	6-8 9/16	56-8⅝	6-0 3/16	5-9 7/16	5-7 5/16	5-6 1/16	5-5 7/16
57-0	55-5	5-6½	58-10 9/16	2-7 3/16	4-6⅜	5-10½	3-8¾	2-11¼	6-11⅛	6-1 7/16	7-1⅞	6-3¼	6-3¼	6-9 15/16	57-8⅜	6-1 7/16	5-10½	5-8 7/16	5-7 3/16	5-6⅝
58-0	56-5½	5-7¾	59-11⅞	2-7¾	4-7 7/16	5-11⅞	3-9½	2-11 15/16	7-0 11/16	6-2 13/16	7-3 9/16	6-4 11/16	6-4 11/16	6-11 7/16	58-9⅜	6-2 13/16	5-11 13/16	5-9¾	5-8 7/16	5-7⅞
59-0	57-6	5-9	61-1⅛	2-8 5/16	4-8 7/16	6-1⅛	3-10 7/16	3-0 9/16	7-2¼	6-4 3/16	7-5 13/16	6-6 1/16	6-6 1/16	7-1⅞	59-10⅜	6-4¼	6-1⅛	5-11	5-9¾	5-9 [illegible]
60-0	58-6½	5-10¼	62-2 7/16	2-8⅞	4-9 7/16	6-2 7/16	3-11 5/16	3-1¼	7-3 13/16	6-5 9/16	7-6¾	6-7½	6-7½	7-2 9/16	60-11⅜	6-5 9/16	6-2 7/16	6-0 5/16	5-11	5-10⅜
61-0	59-5¾	5-11⅜	63-2⅜	2-9 7/16	4-10⅜	6-3⅝	4-0 1/16	3-1 13/16	7-5¼	6-6 13/16	7-8 3/16	6-8¾	6-8¾	7-4	61-11⅛	6-6 13/16	6-3⅝	6-1½	6-0⅛	5-11½

12 PANEL

Bevel A = 6⅜ to 12
B = 5¼ to 12
C = 3 13/16 to 12
D = 2⅞ to 12
E = 1⅞ to 12
F = 0 15/16 to 12

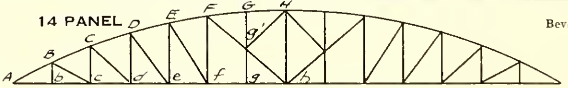


Bevel B-c = 5¾ to 12
C-d = 10¼ to 12
D-e = 12 to 10½
E-f' = 8 1/16 to 12
f'-g = 8 1/16 to 12
f'-G = 9 13/16 to 12

Bldg. Width	Truss Span	Panel Length	Radius	Vertical Members B-b	C-c	D-d	E-e	F-f'	f'-f	G-g	Diagonal Members B-c	C-d	D-e	E-f'	f'-g	f'-G	Lengths of Arcs Whole Arc	A-B	B-C	C-D	D-E	E-F	F-G
62-0	60-6	5-0½	64-3⅜	2-4 15/16	4-3 13/16	5-9⅛	6-9 3/16	3-11¾	3-4⅝	7-6¾	5-7 1/16	6-7 11/16	7-7⅞	6-0⅞	6-0⅞	6-6 9/16	62-11⅞	5-7⅛	5-4 11/16	5-2 [illegible]	5-1¾	5-0 13/16	5-0½
63-0	61-6	5-1½	65-4⅛	2-5 7/16	4-4 11/16	5-10¼	6-10 9/16	4-0½	3-5 5/16	7-8¼	5-8 3/16	6-9	7-9⅜	6-2 1/16	6-2 1/16	6-7⅞	64-0⅜	5-8 3/16	5-5¾	5-4	5-2¾	5-1 13/16	5-1 9/16
64-0	62-6	5-2½	66-4⅞	2-5 15/16	4-5½	5-11⅜	6-11⅞	4-1⅜	3-5 15/16	7-9¾	5-9 5/16	6-10¼	7-10⅞	6-3¼	6-3¼	6-9 3/16	65-0⅞	5-9 5/16	5-6 13/16	5-5	5-3¾	5-3	5-2 9/16
65-0	63-6	5-3½	67-5⅝	2-6⅜	4-6⅜	6-0½	7-1¼	4-2⅛	3-6⅝	7-11¼	5-10⅜	6-11⅝	8-0⅜	6-4½	6-4½	6-10½	66-1⅜	5-10 7/16	5-7⅞	5-6 1/16	5-4¾	5-4	5-3 9/16
66-0	64-6	5-4½	68-6⅜	2-6⅞	4-7¼	6-1 11/16	7-2 9/16	4-2⅞	3-7 5/16	8-0¾	5-11½	7-0 15/16	8-1 15/16	6-5 11/16	6-5 11/16	6-11¾	67-1⅞	5-11 9/16	5-8 [illegible]	5-7⅛	5-5 13/16	5-4 15/16	5-4 9/16
67-0	65-6	5-5½	69-7⅛	2-7⅜	4-8⅛	6-2 13/16	7-3 15/16	4-3 11/16	3-8	8-2¼	6-0⅝	7-2¼	8-3 7/16	6-6⅞	6-6⅞	7-1 1/16	68-2⅜	6-0 11/16	5-10	5-8⅛	5-6 [illegible]	5-6	5-5 9/16
68-0	66-6	5-6½	70-7⅞	2-7 13/16	4-8 15/16	6-3 15/16	7-5¼	4-4½	3-8⅝	8-3¾	6-1¾	7-3 9/16	8-4 15/16	6-8 1/16	6-8 1/16	7-2⅜	69-2⅞	6-1¾	5-11 [illegible]	5-9 3/16	5-7⅞	5-7	5-6 9/16
69-0	67-6	5-7½	71-8⅝	2-8 5/16	4-9 13/16	6-5 1/16	7-6⅝	4-5 5/16	3-9 5/16	8-5¼	6-2⅞	7-4⅞	8-6 7/16	6-9 5/16	6-9 5/16	7-3 11/16	70-3⅜	6-2⅞	6-0⅛	5-10¼	5-8⅞	5-8	5-7 [illegible]
70-0	68-6	5-8½	72-9⅜	2-8 13/16	4-10 11/16	6-6¼	7-7 15/16	4-6 1/16	3-10	8-6¾	6-3 15/16	7-6 3/16	8-8	6-10½	6-10½	7-5	71-3⅞	6-4	6-1 3/16	5-11¼	5-9⅞	5-9	5-8⅝
71-0	69-6	5-9½	73-10⅛	2-9¼	4-11½	6-7⅜	7-9¼	4-6⅞	3-10⅝	8-8¼	6-5 1/16	7-7½	8-9½	6-11 11/16	6-11 11/16	7-6¼	72-4⅜	6-5⅛	6-2 [illegible]	6-0 [illegible]	5-10 [illegible]	5-10	5-9 [illegible]
72-0	70-6	5-10½	74-10⅞	2-9¾	5-0⅜	6-8½	7-10⅝	4-7 11/16	3-11 5/16	8-9¾	6-6 3/16	7-8 13/16	8-11	7-0⅞	7-0⅞	7-7 9/16	73-4⅞	6-6 3/16	6-3⅜	6-1⅜	5-11 13/16	5-11	5-10 9/16
73-0	71-6	5-11½	75-11⅝	2-10¼	5-1¼	6-9⅝	7-11 13/16	4-8 7/16	4-0	8-11¼	6-7¼	7-10⅛	9-0½	7-2⅛	7-2⅛	7-8⅞	74-5⅜	6-7 1/16	6-4⅜	6-2⅜	6-0 13/16	6-0	5-11 9/16

14 PANEL

Bevel A = 6⅜ to 12
B = 5 5/16 to 12
C = 4 3/16 to 12
D = 3⅜ to 12
E = 2½ to 12
F = 1⅝ to 12
G = 0 13/16 to 12



Bevel B-c = 5⅞ to 12
C-d = 10 11/16 to 12
D-e = 12 to 10
E-f = 12 to 8 [illegible]
F-g' = 9 11/16 to 12
g'-h = 9 11/16 to 12
g'-H = 11 5/16 to 12

Bldg Width	Truss Span	Panel Length	Radius	Vertical Members B-b	C-c	D-d	E-e	F-f	G-g'	g'-g	H-h	Diagonal Members B-c	C-d	D-e	E-f	F-g'	g'-h	g'-H	Lengths of Arcs Whole Arc	A-B	B-C	C-D	D-E	E-F	F-G	G-H
74-0	72-5¾	5-2⅛	77-0 1/16	2-6¼	4-7	6-2 11/16	7-5¾	8-4⅜	4-8 7/16	4-2 3/16	9-0¾	5-9⅛	6-11	8-1⅛	9-1⅛	6-7⅞	6-7⅞	7-1⅜	75-5½	5-9⅛	5-6⅞	5-5 3/16	5-3 15/16	5-3	5-2 7/16	5-2 3/16
75-0	73-6	5-3	78-1⅛	2-6⅝	4-7¾	6-3¾	7-7	8-5¾	4-9¼	4-2⅞	9-2¼	5-10 1/16	7-0⅛	8-2½	9-2 11/16	6-9	6-9	7-2 9/16	76-6¼	5-10 1/16	5-7 13/16	5-6⅛	5-4 13/16	5-3 13/16	5-3 3/16	5-3 1/16
76-0	74-6¼	5-3⅞	79-2⅛	2-7 1/16	4-8½	6-4¾	7-8¼	8-7⅛	4-10 1/16	4-3 9/16	9-3¾	5-11	7-2⅛	8-3⅞	9-4 7/16	6-10 1/16	6-10 1/16	7-3¾	77-7	5-11 1/16	5-8¾	5-7	5-5¾	5-4 13/16	5-4 3/16	5-3 13/16
77-0	75-6½	5-4¾	80-3 3/16	2-7½	4-9¼	6-5⅞	7-9½	8-8⅝	4-10⅞	4-4 5/16	9-5 5/16	6-0	7-2 7/16	8-5¼	9-5⅛	6-11¼	6-11¼	7-5	78-7¾	6-0	5-9 11/16	5-7 13/16	5-6⅝	5-5 11/16	5-5⅛	5-4 13/16
78-0	76-5	5-5½	81-2 5/16	2-7 13/16	4-9 13/16	6-6¾	7-10⅝	8-9 13/16	4-11½	4-4 13/16	9-6⅝	6-0 13/16	7-3½	8-6 7/16	9-7 1/16	7-0 3/16	7-0 3/16	7-6	79-6¾	6-0⅞	5-10½	5-8 11/16	5-7 7/16	5-6 7/16	5-5⅞	5-5 9/16
79-0	77-5¼	5-6⅜	82-3 3/16	2-8¼	4-10 11/16	6-7 15/16	7-11⅞	8-11 3/16	5-0¼	4-5⅝	9-8⅛	6-1¾	7-4⅝	8-7 13/16	9-8⅝	7-1 5/16	7-1 5/16	7-7 3/16	80-7½	6-1 13/16	5-11 7/16	5-9⅝	5-8 3/16	5-7⅜	5-6¾	5-6 7/16
80-0	78-5½	5-7¼	83-4⅜	2-8¾	4-11½	6-8⅞	8-1 3/16	9-0⅝	5-1⅛	4-6 5/16	9-9 11/16	6-2 13/16	7-5 13/16	8-9 3/16	9-10 3/16	7-2 7/16	7-2 7/16	7-8⅜	81-8¼	6-2 13/16	6-0⅜	5-10 9/16	5-9 3/16	5-8¼	5-7⅝	5-7 3/16
81-0	79-5¾	5-8⅛	84-5⅜	2-9⅛	5-0¼	6-9 15/16	8-2 7/16	9-2 1/16	5-1⅞	4-7 1/16	9-11¼	6-3¾	7-6 13/16	8-10 9/16	9-11 11/16	7-3 9/16	7-3 9/16	7-8⅝	82-9	6-3 15/16	6-1 5/16	5-11 7/16	5-10⅛	5-9⅛	5-8½	5-8 3/16
82-0	80-6	5-9	85-6⅜	2-9 9/16	5-1 1/16	6-10 13/16	8-3 11/16	9-3 7/16	5-2 11/16	4-7¾	10-0¾	6-4¾	7-8⅛	8-11⅞	10-1¼	7-4 11/16	7-4 11/16	7-10¾	83-9¾	6-4¾	6-2 5/16	6-0⅜	5-11	5-10	5-9⅜	5-9 1/16
83-0	81-6¼	5-9⅞	86-7⅜	2-9 15/16	5-1 13/16	7-0	8-4 13/16	9-4 13/16	5-3½	4-8 7/16	10-2¼	6-5 11/16	7-9 5/16	9-1¼	10-2¾	7-5 13/16	7-5 13/16	8-0	84-10½	6-5¾	6-3 3/16	6-1 5/16	5-11 13/16	5-10⅞	5-10¼	5-9 13/16
84-0	82-6½	5-10¾	87-8⅜	2-10 7/16	5-2⅝	7-1	8-6⅛	9-6¼	5-4 5/16	4-9⅛	10-3 13/16	6-6 11/16	7-10½	9-2⅝	10-4¼	7-6 13/16	7-6 13/16	8-1¼	85-11¼	6-6¾	6-4 3/16	6-2¼	6-0 13/16	5-11 13/16	5-11⅛	5-10 13/16
85-0	83-5	5-11½	88-7 9/16	2-10¾	5-3¼	7-1 13/16	8-7¼	9-7½	5-5	4-9¾	10-5⅛	6-7½	7-11 7/16	9-3 13/16	10-5 9/16	7-7 13/16	7-7 13/16	8-2¼	86-10¼	6-7 9/16	6-5	6-3	6-1 9/16	6-0 9/16	5-11⅞	5-11 9/16
86-0	84-5¼	6-0⅜	89-8 9/16	2-11 3/16	5-4	7-3	8-8½	9-8⅞	5-5¾	4-10 7/16	10-6⅝	6-8½	8-0⅝	9-5 3/16	10-7⅛	7-9	7-9	8-3 7/16	87-11	6-8½	6-5 15/16	6-3 13/16	6-2½	6-1 7/16	6-0¾	6-0 7/16
87-0	85-5½	6-1¼	90-9 11/16	2-11⅝	5-4 13/16	7-4 1/16	8-9¾	9-10 5/16	5-6 9/16	4-11 3/16	10-8 3/16	6-9 7/16	8-1 13/16	9-6 9/16	10-8⅝	7-10⅛	7-10⅛	8-4⅝	88-11¾	6-9½	6-6⅞	6-4⅞	6-3⅜	6-2 5/16	6-1⅝	6-1 5/16
88-0	86-5¾	6-2⅛	91-10⅝	3-0	5-5 9/16	7-5⅛	8-11 1/16	9-11¾	5-7⅜	4-11⅞	10-9¾	6-10⅜	8-3	9-7 13/16	10-10¼	7-11 3/16	7-11 3/16	8-5⅞	90-0½	6-10½	6-7 13/16	6-5¾	6-4¼	6-3¼	6-2½	6-2 3/16
89-0	87-6	6-3	92-11⅝	3-0 7/16	5-6 5/16	7-6⅛	9-0 5/16	10-1⅛	5-8 5/16	5-0 9/16	10-11¼	6-11⅜	8-4⅛	9-9¼	10-11¾	8-0⅜	8-0⅜	8-7 1/16	91-1¼	6-11 7/16	6-8¾	6-6 11/16	6-5 5/16	6-4⅛	6-3⅜	6-3 1/16
90-0	88-6¼	6-3⅞	94-0⅝	3-0⅞	5-7⅛	7-7 3/16	9-1 9/16	10-2½	5-8 15/16	5-1¼	11-0¾	7-0⅜	8-5 5/16	9-10⅝	11-1¼	8-1½	8-1½	8-8¼	92-2	7-0 7/16	6-9 13/16	6-7⅝	6-6 1/16	6-5	6-4¼	6-3 13/16

STRESSES IN BOWSTRING TRUSSES

HEIGHT ⅛ SPAN

CIRCULAR ARC DESIGN

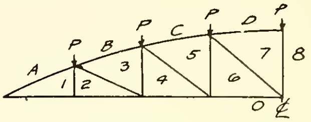
FOR UNIFORM LOADING

The stress in any member equals the coefficient given for that member multiplied by P, the Panel Load.

+ Denotes compression.
— Denotes tension.

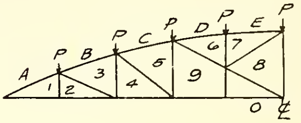
STRESS COEFFICIENTS FOR 8 PANEL TRUSS

	Kind Stress	Coeff.		Kind Stress	Coeff.		Kind Stress	Coeff.
A-1	+	8.47	0-4	—	7.87	6-7	—	.04
B-3	+	8.24	0-6	—	7.97	3-4	+	.07
C-5	+	8.10	2-3	—	.17	5-6	+	.08
D-7	+	8.02	4-5	—	.13	7-8	+	.05
01-2	—	7.72						



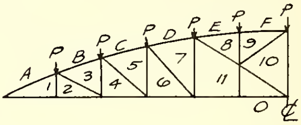
STRESS COEFFICIENTS FOR 10 PANEL TRUSS

	Kind Stress	Coeff.		Kind Stress	Coeff.		Kind Stress	Coeff.
A-1	+	10.61	0-4	—	9.79	7-8	—	.06
B-3	+	10.37	0-9	—	9.90	3-4	+	.07
C-5	+	10.19	2-3	—	.16	5-9	+	.09
D-6	+	10.15	4-5	—	.15	6-7	+	.06
E-7	+	10.06	6-9	—	.16	8-10	+	.11
01-2	—	9.61	8-9	—	.11			



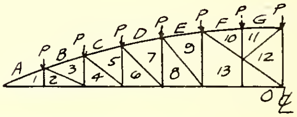
STRESS COEFFICIENTS FOR 12 PANEL TRUSS

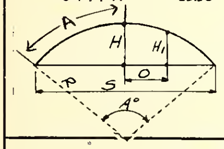
	Kind Stress	Coeff.		Kind Stress	Coeff.		Kind Stress	Coeff.
A-1	+	12.75	0-4	—	11.68	10-11	—	.09
B-3	+	12.48	0-6	—	11.82	9-10	—	.04
C-5	+	12.29	0-11	—	11.92	3-4	+	.08
D-7	+	12.16	2-3	—	.20	5-6	+	.12
E-8	+	12.12	4-5	—	.18	7-11	+	.12
F-9	+	12.04	6-7	—	.16	8-9	+	.04
01-2	—	11.50	8-11	—	.12	10-12	+	.11



STRESS COEFFICIENTS FOR 14 PANEL TRUSS

	Kind Stress	Coeff.		Kind Stress	Coeff.		Kind Stress	Coeff.
A-1	+	14.87	0-6	—	13.73	12-13	—	.09
B-3	+	14.60	0-8	—	13.85	11-12	—	.04
C-5	+	14.41	0-13	—	13.94	3-4	+	.09
D-7	+	14.25	2-3	—	.21	5-6	+	.12
E-9	+	14.14	4-5	—	.22	7-8	+	.15
F-10	+	14.11	6-7	—	.19	9-13	+	.12
G-11	+	14.04	8-9	—	.15	10-11	+	.05
01-2	—	13.38	10-13	—	.12	12-14	+	.11
0-4	—	13.56						





The Coefficients in the above table are for Circular Arc Trusses with characteristics as follows:

S = Span = $2\sqrt{R^2 (R-H)^2} = 2\sqrt{2HR-H^2} = 2R\sin\frac{A^\circ}{2}$

H = Height at Center = $\frac{1}{8}S = R-\frac{1}{2}\sqrt{4R^2-S^2} = \frac{S}{2}\tan\frac{A^\circ}{4} = 2R\sin^2\frac{A^\circ}{4}$; $A^\circ = 56^\circ\text{-}8.7'$

H_{1-2} etc. = Side Ordinates = $\sqrt{R^2-O^2}+H-R$

R = Radius = $\frac{4H^2+S^2}{8H} = 8.5H$

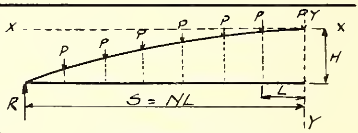
$a = \text{Arc} = \frac{\pi R A^\circ}{180} = .017453RA^\circ$
$= 1.04116S = .97991R$

PARABOLIC BOWSTRING TRUSSES

If the top chord of a bowstring truss is bent to the form of a parabolic curve, there will be no web stresses under uniform load.

NO STRESS IN WEB MEMBERS

UNDER UNIFORM LOADING



Let "K" = number panels from left support to any point of Moment (O)

Height at O = H-y = $\frac{KL(2N-K)}{4N}$

φ = Angle upper chord makes with horiz.,

tan φ = $\frac{\frac{KL(2N-K)}{4N} - \frac{L(2KN-2N-K^2+2K-1)}{4N}}{L} = \frac{2N-2K+1}{4N}$

Vert. comp. of stress in chord = $\frac{P}{2}(2N-2K+1)$

Vert. shear in panel = $\frac{P}{2}(2N-2K+1)$

Horiz. comp of stress in chord = $\frac{\frac{P(2N-1)KL}{2} - \frac{PL(K)(K-1)}{2}}{\frac{KL(2N-K)}{4N}}$

S = Half Span, as shown

H = $\frac{S}{4} = \frac{NL}{4}$

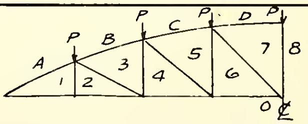
R = Reaction = $\frac{P(2N-1)}{2}$

Equation of Curve: $X^2 = 4NLY$

N = Number panels in half truss

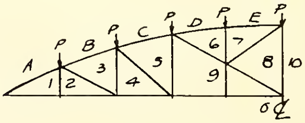
8 PANEL TRUSS

CHORD STRESS COEFFICIENTS		VERTICAL HEIGHT COEFFICIENTS	
A-1	+ 8.73	1-2	.4375 H
B-3	+ 8.38	3-4	.7500 H
C-5	+ 8.14	5-6	.9375 H
D-7	+ 8.02		
0-1-2	— 8.00		



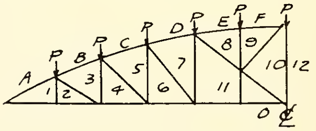
10 PANEL TRUSS

CHORD STRESS COEFFICIENTS		VERTICAL HEIGHT COEFFICIENTS	
A-1	+ 10.96	1-2	.3600 H
B-3	+ 10.59	3-4	.6400 H
C-5	+ 10.31	5-9	.8400 H
D-6	+ 10.11	6-7-9	.9600 H
E-7	+ 10.01		
0-1-2	— 10.00		



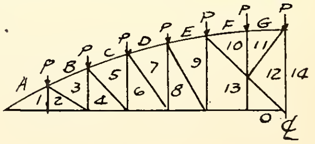
12 PANEL TRUSS

CHORD STRESS COEFFICIENTS		VERTICAL HEIGHT COEFFICIENTS	
A-1	+ 13.20	1-2	.3056 H
B-3	+ 12.82	3-4	.5556 H
C-5	+ 12.50	5-6	.6944 H
D-7	+ 12.26	7-11	.8889 H
E-8	+ 12.09	8-9-11	.9722 H
F-9	+ 12.01		
0-1-2	— 12.00		

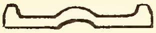


14 PANEL TRUSS

CHORD STRESS COEFFICIENTS		VERTICAL HEIGHT COEFFICIENTS	
A-1	+ 15.44	1-2	.2653 H
B-3	+ 15.04	3-4	.4898 H
C-5	+ 14.71	5-6	.6735 H
D-7	+ 14.43	7-8	.8163 H
E-9	+ 14.22	9-13	.9184 H
F-10	+ 14.08	10-11-13	.9796 H
G-11	+ 14.01		
0-1-2	— 14.00		



STRUCTURAL ROOF MATERIALS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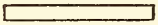
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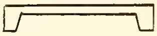
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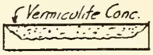

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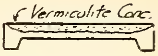


TYPE 5

TRUSCON

TRUSCON	CEMENT ROOFING TILE					THERMO-SLAB TILE		
	TYPE 1 Rib Tile	TYPE 2 Flat Slab	TYPE 3 2¾" [-Tile	TYPE 3 3¾" [-Tile	TYPE 3 3¾" [-Tile	TYPE 4 Flat Slab	TYPE 5 3¾" [-Tile	TYPE 5 4¾" [-Tile
WIDTH	24"	24"	24"	24"	18"	24"	24"	24"
LENGTH	4'-4"	5'-0"	6'-8" Max.	8'-0" Max.	9'-0" Max.	5'-0"	6'-8"	8'-0"
WEB THICKNESS	1⅛"	1⅝"	1"	1"	1"	2½"	2"	2"
LEG DEPTH				2¾"	3¾"		3¾"	4¾"
WEIGHT—HAYDITE	16 lbs. s.f.	13.5 lbs. s.f.	10.5 lbs. s.f.	12 lbs. s.f.	13.5 lbs. s.f.	16 lbs. s.f.	14 lbs. s.f.	16 lbs. s.f.
WEIGHT—SAND	17 lbs. s.f.	19 lbs. s.f.	16 lbs. s.f.	17.5 lbs. s.f.	19 lbs. s.f.			
REINFORCING	Weld. galv. mesh	Weld. galv. mesh	Mesh and bars	Mesh and bars	Mesh and bars	Weld. galv. bars	Mesh and bars	Mesh and bars
ROOF PITCH	1-5 pitch or more	Flat or pitched	Flat or pitched	Flat or pitched	Flat or pitched	Flat or pitched	Flat or pitched	Flat or pitched
ROOFING	Self weathering	Comp. roof req'd	Comp. roof req'd	Comp. roof req'd	Comp. roof req'd	Comp. roof req'd	Comp. roof req'd	Comp. roof req'd
PURLIN SPACING	3'-9" to 4'-0½"	5'-0" maximum	6'-8" maximum	8'-0" maximum	9'-0" maximum	5'-4" maximum	6'-8" maximum	8'-0" maximum

FEDERAL CEMENT TILE

Properties and dimensions of "Red Interlocking Tile" similar to Type 1 above. Standard Tile 24"x52"x1⅛"; weight 16 lbs. sq. ft.; purlin spacing 3'-9" to 4'-0½".

"Featherweight Nailing Concrete Slab" similar to Type 4. Standard size 24"x2½"; maximum length 5'-4"; weight 19 lbs. sq. ft.

"Featherweight Channel Slabs" similar to Type 3. Size 24"x2¾"—6'-4" maximum length, weighs 12 lbs. sq. ft.; 24"x3½"—8'-4" maximum length, weighs 14 lbs sq. ft. All Federal Tile designed for Ultimate Load of 250 lbs. sq. ft.

UNITED STATES GYPSUM

2½"x10"x6'-0" TONGUE & GROOVE GYPSUM ROOF TILE

Dimensions			Weight Sq. Foot Pounds	All. Load Sq. Foot Pounds	Allowable Span	Thermal Conductivity—Btu Per Sq. Ft. Per Hr. Per Deg. F.		
Thickness	Width	Length				No Insulation	½" Insulation	1" Insulation
2½"	10"	6'-0"	15	50	4'-0"	0.47	0.28	0.19

3" SHORT SPAN GYPSUM ROOF TILE

3" SHORT SPAN GYPSUM ROOF TILE				
Dimensions			Weight Sq. Foot Pounds	All. Load Sq. Foot Pounds
Thickness	Width	Length		
3"	12"	30"	17	55

THERMAL CONDUCTIVITY		
No Insulation	½" Weatherwood	1" Weatherwood
0.48	0.28	0.19

STEEL SUB-PURLINS Spacing 2'-6¾" cts. Total Roof Load 55 Lbs. Sq. Ft.				
Size and Section Modulus of Sub-Purlins	Weight Lin. Ft. Sub-Purlin	Weight Sq. Foot Roof	Allowable Span	
			18000 Stress	20000 Stress
USG No. 178 Bulb Tee. S = .348	2.66	1.03	6'-1"	6'-5"
USG No. 218 Bulb Tee. S = .450	2.80	1.08	6'-11"	7'-3"
2½x2½x5/16 Tee. S = .500	5.50	2.15	7'-3"	7'-8"
2½x3x5/16 Tee. S = .720	6.10	2.40	8'-9"	9'-3"
3x3x5/16 Tee. S = .740	6.70	2.61	8'-10"	9'-4"

2"x15"x10'-0" METAL EDGE GYPSUM PLANK

Dimensions			Weight Per Sq. Ft.	All. Load Sq. Foot	Allowable Span	Thermal Conductivity—Btu Per Sq. Ft. Per Hr. Per Deg. F.		
Thickness	Width	Length				No Insulation	½" Insulation	1" Insulation
2"	15"	10'-0"	12 lbs.	75 lbs.	7'-0"	0.53	0.29	0.20

SHEET ROCK PYROFILL ROOF DECK

SUB-PURLINS Spac. 32⅝"	Sec. Mod.	Allowable Span		Weight Sub-Purlins Lbs. Sq. Ft.	Weight of Slab, Including Sub-Purlins					
		18000 Stress	20000 Stress		Sheetrock Pyrofill		Weatherwood Pyrofill		Asbestos Bd. Pyrofill	
					Thickness	Wt. Sq. Ft.	Thickness	Wt. Sq. Ft.	Thickness	Wt. Sq. Ft.
USG No. 178 Bulb Tee	.348	6'-6"	6'-10"	1.00	2½"	11.5	3"	10.5	2½"	11.5
USG No. 218 Bulb Tee	.450	7'-5"	7'-10"	1.03	2½"	11.5	3"	10.5	2½"	11.5
12-lb. ASCE Rail	.630	8'-11"	9'-3"	1.50	2½"	12.0	3"	11.0	2½"	12.0
16 lb. ASCE Rail	1.01	11'-2"	11'-6"	2.0	2½"	12.5	3"	11.5	2½"	12.5
20 lb. ASCE Rail	1.43	13'-3"	13'-8"	2.5	3"	15.0	3"	12.0	3"	15.0

ZONOLITE

ZONOLITE STRUCTURAL CONCRETE ROOF DECK

Maximum Span	Total Slab Thickness	Effective Depth Slab	MAIN STEEL			TEMPERATURE STEEL			Total Weight Slab	Thermal Conductivity
			Required Area	Size	Spacing	Required Area	Size	Spacing		
3'0"	3"	2"	0.144	¼φ	4"	0.072	¼φ	8"	15	0.170
4'-0"	3"	2"	0.144	¼φ	4"	0.072	¼φ	8"	15	0.170
5'-0"	3½"	2½"	0.180	⅜φ	7½"	0.084	¼φ	7"	16	0.152
6'-0"	4"	3"	0.216	⅜φ	6"	0.096	⅜φ	12"	18	0.137
7'-0"	4½"	3½"	0.252	⅜φ	5"	0.108	⅜φ	12"	19	0.124
8'-0"	5"	4"	0.288	⅜φ	4½"	0.120	⅜φ	11"	20	0.114
9'-0"	5¾"	4¾"	0.342	⅜φ	3¾"	0.138	⅜φ	9½"	22	0.101

CELOTEX

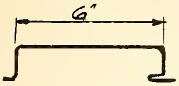
CEMESTO ROOF DECK

Thickness	Weight Sq. Ft.	U-Value	Total Load
1 9/16"	4.8 Lb.	0.186	50 Lb. Sq. Ft.
2"	5.3 Lb.	0.149	50 Lb. Sq. Ft.

Made of Celotex, surfaced with ⅛" cement-asbestos both sides. Sheets 4'-0" wide; maximum length between headers 8'-0". Requires fastening 4 sides; either clips to steel or nail to wood nailer strips. Consult "Celotex" for details.

STRUCTURAL ROOF MATERIALS

STEEL ROOF DECK



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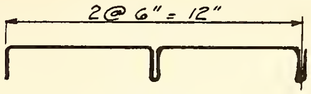

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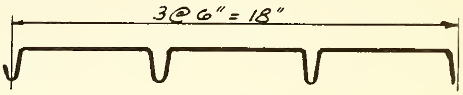


TYPE 3

Type 1, as produced by Truscan (Ferrobord) comes in depths of 1½" and 1¾", in both 18 and 20 gage. R. C. Mahon Co. makes Type 2, same gages, in 1½" depth. Type 3 is manufactured by many companies, such as Detroit Steel Products (Fenestra) 1½" deep, 18-20 gage; Goldsmith Metal Lath Co. (Metrodeck) 1½" and 1¾" deep, 18-20-22 gage; Milcor Steel Co. (Milcor) same depths and gage as Metrodeck; U. S. Gypsum (U.S.G.) same depths and gages as Fenestra; and Wheeling Corrugating (Tri-Rib) who make depths of 1½", 1¾", 2" and 2½", in 18-20-22 gages.

Due to difference in design of the individual rib, the lap, etc., there can be little uniformity in safe load tables. The manufacturer should be consulted for all details concerning his product. The accompanying tables are offered for reference.

The 1¾" deep rib will carry same load on 10'-0" span as 1½" rib on 9'-0"

METRODECK

DEPTH OF RIB	GAGE	TOTAL SAFE LOAD, LBS. SQ. FT. FOR PURLIN SPACING SHOWN												
		3'-0"	3'-6"	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	8'-6"	9'-0"
1½"	22	252	185	142	112	91	75	63	54	46	40	35	31	23
	20	300	221	169	133	108	89	75	64	55	48	42	37	33
	18	395	290	222	175	142	118	99	84	73	63	56	49	44
1¾"	22	310	228	174	138	111	92	77	66	57	50	44	39	34
	20	369	272	208	164	133	110	92	79	68	59	52	46	41
	18	487	358	274	216	175	145	122	104	89	78	68	61	54

MILCOR

GAGE	RIB SPC.G	WEIGHT 100 SQ. FT.		TOTAL SAFE LOAD, LBS. SQ. FT., FOR PURLIN SPACING AND RIB DEPTH SHOWN																	
				4'-0"		4'-6"		5'-0"		5'-6"		6'-0"		6'-6"		7'-0"		7'-6"		8'-0"	
		1½	1¾	1½	1¾	1½	1¾	1½	1¾	1½	1¾	1½	1¾	1½	1¾	1½	1¾	1½	1¾	1½	1¾
22	6"	180		79		62		50		41		35		30							
20	6"	222	233	95		75		62	80	50	65	42	55	36	47	31	40				
18	6"	295	310	125		100		81		67	87	56	73	48	62	41	53	36	45	31	38

Allowance of 5 lbs. sq. ft. for Dead Load

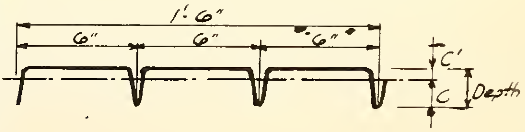
U. S. G.

Btu values are per sq. ft., per hr., per deg. F.

GAGE	B₁M₁	ALLOWABLE LOAD, LBS. SQ. FT. FOR PURLIN SPACING SHOWN							INSULATION VALUE B. T. U.			
		5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	No Insulation	½" Weatherwood	1" Weatherwood	1½" Weatherwood
20	1/8 WL	81	67	56	48	41			0.94	0.39	0.24	0.18
	1/10 WL	102	85	71	61	52	44	38				
18	1/8 WL			71	60	52	45	39	0.94	0.39	0.24	0.18
	1/10 WL			90	76	66	57	50				

TRI-RIB

DEPTH	GAGE	PER FOOT WIDTH: MOMENT OF INERTIA	PER FOOT WIDTH: SECTION MODULUS	PER FOOT WIDTH: RESISTING MOMENT INCH LBS.	C INS.	C' INS.
1½"	18	.1784	.149	2680	1.195	.305
	20	.1333	.111	1998	1.198	.302
	22	.1129	.094	1692	1.198	.302
1¾"	18	.2704	.198	3564	1.37	.38
	20	.2004	.146	2630	1.37	.38
	22	.1695	.124	2230	1.37	.38
2"	18	.3864	.2516	4520	1.537	.463
	20	.2860	.1862	3350	1.536	.464
2½"	18	.7001	.375	6750	1.86	.64
	20	.5164	.277	5000	1.86	.64



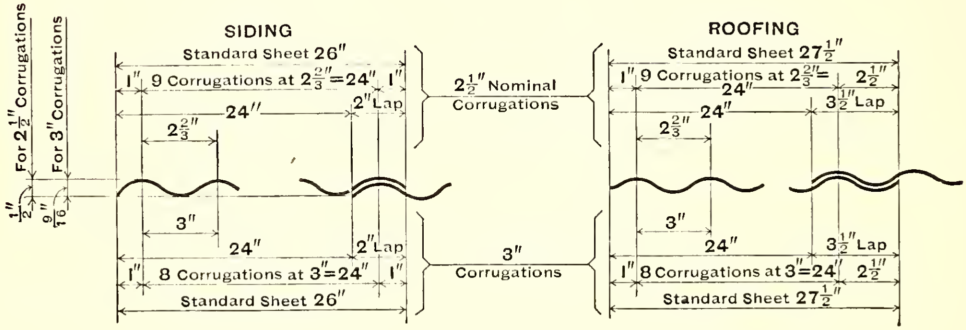
COURTESY, "AMERICAN INSTITUTE OF STEEL CONSTRUCTION"

CORRUGATED SHEET METAL CONSTRUCTION

Corrugated steel, in addition to its extensive application as roofing and siding for buildings, is adaptable to other varied requirements such as lining of shafts, supports and forms for floor arches, partitions, enclosures and culverts.

Corrugated sheets are available in steel of regular analysis or in rust-resisting alloys, usually copper-bearing steel, either black (unpainted mill finish), painted or galvanized. Although the mills offer a wide choice in types and widths of corrugations, the curved type illustrated below is generally used. Standard lengths range from 60 inches to a maximum of 144 inches varying by 12 inches. Other lengths are available but subject to an extra charge.

DATA FOR ESTIMATING ROOFING AND SIDING


For $2\frac{1}{2}''$ Corrugations
For $3''$ Corrugations
$\frac{1}{2}''$
$\frac{9}{16}''$
SIDING
Standard Sheet $26''$
$1''$ 9 Corrugations at $2\frac{2}{3}''=24''$ $1''$
$24''$
$2''$ Lap
$2\frac{2}{3}''$
$3''$
$24''$
$2''$ Lap
$1''$ 8 Corrugations at $3''=24''$ $1''$
Standard Sheet $26''$
$2\frac{1}{2}''$ Nominal Corrugations
$3''$ Corrugations
ROOFING
Standard Sheet $27\frac{1}{2}''$
$1''$ 9 Corrugations at $2\frac{2}{3}''=24''$ $2\frac{1}{2}''$
$24''$
$3\frac{1}{2}''$ Lap
$2\frac{2}{3}''$
$3''$
$24''$
$3\frac{1}{2}''$ Lap
$1''$ 8 Corrugations at $3''=24''$ $2\frac{1}{2}''$
Standard Sheet $27\frac{1}{2}''$

Corrugations: Nominal widths, $2\frac{1}{2}$ inches (actual $2\frac{2}{3}$ inches), are preferred for domestic work and 3 inch widths for export.

Roofing sheet is $27\frac{1}{2}$ inches wide after corrugating and has one edge turned up and the other down. It is laid with a side lap of $1\frac{1}{2}$ corrugations (covering approximately 24 inches net width) and a minimum end lap of 6 inches for roof pitch of 4 inches in 12 inches or over. For roofs under 4 inch pitch the minimum end lap should be 8 inches.

Corrugated steel roofing is seldom used for roof pitch under 3 inches in 12 inches.

Siding sheet is 26 inches wide after corrugating and has both edges of sheet turned the same way. It is laid with a side lap of one corrugation (covering approximately 24 inches net width) and a minimum end lap of 4 inches.

For export work, roofing and siding are frequently furnished with 3 inch corrugations and in 32 inch widths, covering 27 inches net when laid with 2 corrugations side lap, and 30 inches net with one corrugation side lap.

Sheet steel flashing must be provided at roof ridge, eaves, windows and wherever necessary to insure watertight results.

The following approximate method of obtaining the gross area required may be used:

Roofing = Net area + end laps + 15% for side laps of $1\frac{1}{2}$ corrugations.
Siding = Net area + end laps + 10% for side laps of 1 corrugation.

COURTESY, "AMERICAN INSTITUTE OF STEEL CONSTRUCTION"

CORRUGATED SHEET METAL CONSTRUCTION

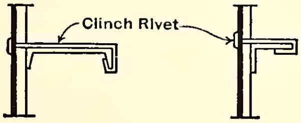
Gage U. S. Standard	Thickness Inches	Permissible Variation + or — % of Wt.	Flat Sheets Pounds per Sq. Ft.		2½″ and 3″ Corrugations					
					26″ Sheets Pounds per Sq. Ft.		27½″ Sheets Pounds per Sq. Ft.		Maximum Span Between Supports	
			Galv.	Black	Galv.	Black	Galv.	Black	Roofing	Siding
12	.107	5.0	4.53	4.38	4.88	4.71	4.94	4.77	5′9″	5′10″
14	.077	5.0	3.28	3.13	3.53	3.37	3.58	3.41	5′9″	5′10″
16	.061	5.0	2.66	2.50	2.86	2.69	2.90	2.73	5′9″	5′10″
18	.049	3.5	2.16	2.00	2.32	2.15	2.35	2.18	5′9″	5′10″
20	.037	3.5	1.66	1.50	1.78	1.62	1.81	1.64	5′9″	5′10″
21	.034	3.5	1.53	1.38	1.65	1.48	1.67	1.50	5′9″	5′10″
22	.031	3.5	1.41	1.25	1.51	1.35	1.53	1.36	4′9″	5′10″
23	.028	2.5	1.28	1.13	1.38	1.21	1.40	1.23	4′9″	5′10″
24	.025	2.5	1.16	1.00	1.25	1.08	1.26	1.09	3′9″	4′10″
25	.021	2.5	1.03	.88	1.11	.94	1.13	.96	3′9″	4′10″
26	.018	2.5	.91	.75	.98	.81	.99	.82	2′9″	3′10″
28	.015	2.5	.78	.63	.84	.67	.85	.68	2′9″	3′10″

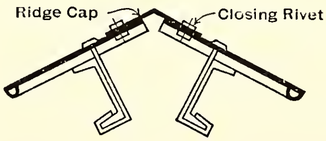
To obtain the weight of black painted sheets, add 0.015 lb. per sq. ft. to weight of black sheets.

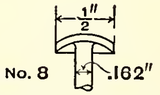
Corrugated metal for export work is usually specified to Birmingham (B.G.) gage.

Permissible variations conform with tolerances adopted by the Association of American Steel Manufacturers in 1929 and apply to weight of steel sheets ordered by weight or gage number.

FASTENINGS FOR CORRUGATED STEEL



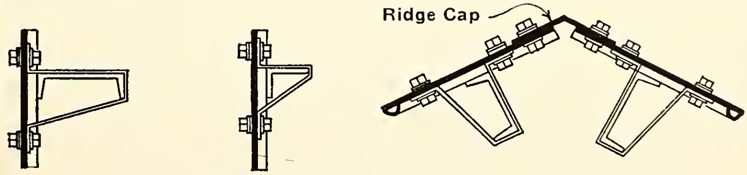




Umbrella Head Clinch Rivet
Maximum Length 15½″

Clinch rivets shown above are frequently used where high winds are not anticipated. Closing rivets, $\frac{3}{16}$″ dia. and driven cold, are used for riveting side and end laps.

In most localities, the fastenings shown below are the required standard.



¼′ Galv. Bolts; Galv. Washers with Lead or Asphalt Saturated Felt Washers underneath

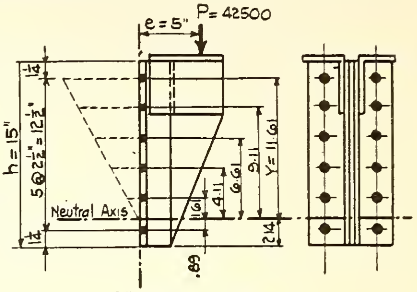
18 Ga. Galv. Metal Straps, 1″ wide.

BRACKET CONNECTIONS

There are several methods of figuring stresses in bracket rivets connecting to column; two are given here, namely, that of Prof. C. R. Young in "Structural Problems", and that suggested by Wm. R. Osgood in "Engineering and Contracting", Vol. LXII, p. 589, December, 1928.

It is desired to find both the maximum tensile and shearing stresses, which will be in the top rivets. The notation:

P = Vertical load on bracket.
e = Dist. from "P" to con. face of bracket.
A = Cross sectional area of one rivet.
N = Total number of rivets in group.
y = Distance from neutral axis to any rivet.
Y = Distance from neutral axis to top rivet.
p = Rivet pitch, when uniformly spaced.
f_t = Maximum tensile stress, top rivets.
f_s = Maximum shearing stress, top rivets.



Young's Method

YOUNG'S METHOD:

Turning is assumed about a center of compression 1/21 of the bracket depth from the bottom; the neutral axis is therefore 3/21 or 1/7 of the bracket depth up from the bottom of the bracket.

The total turning moment is $M = Pe$. The rivets in Tension will therefore resist a moment of $M' = \dfrac{M}{1+\dfrac{2h\Sigma y}{21\Sigma y^2}}$, where "$h$" = total depth of bracket, out to out, and "y" = distance each rivet from neutral axis.

The tension on top rivet, maximum $= \dfrac{M'Y}{\Sigma y^2}$

Example:

Assume bracket as shown, carrying load of 42,500# at a distance of 5″ from face. 12 rivets will be considered, spaced 2½″ centers, size ¾″, with value in tension of 13,500#/□″, and 10,000#/□″ in shear. Neutral axis is at a point 15÷7 = 2.14″ from bottom. Turning moment is 5×42,500 = 212,500″/#s.

$$\Sigma y = 2(1.61+4.11+6.61+9.11+11.61) = 66.1 \text{ in.}$$

$$\Sigma y^2 = 2(1.61^2+4.11^2+6.61^2+9.11^2+11.61^2) = 562.0 \text{ in.}^2.$$

$$M' = \frac{212{,}500}{1+\dfrac{2\times 15\times 66.1}{21\times 562}} = 182{,}000''/\#\text{s.} \quad \text{Tension on rivet} = \frac{182{,}000\times 11.61}{562} = 3{,}760\#.$$

$$\text{Existing tension, per } \square'' = \frac{3{,}760}{0.442} = 8{,}500\#/\square''. \quad \text{Existing shear, per } \square'' = \frac{42{,}500}{12\times 0.442} = 8{,}000\#/\square''$$

The maximum allowable tensile stress due to combined shear and tension:

$$f_t \text{ max.} = f_t\left[\frac{1}{2}+\sqrt{\frac{1}{4}+\frac{f_s^2}{f_t^2}}\right] = 8{,}500\left[0.5+\sqrt{.25+\frac{8{,}000^2}{8{,}500^2}}\right] = 13{,}300\#/\square''$$

OSGOOD'S METHOD:

Turning is assumed about the lower rivet; the distance "Y" is therefore the distance between extreme rivets, or in this case 12½″.

$$f_t = \frac{P'eY}{4A\Sigma y^2}\left[1+\sqrt{1+\left(\frac{4\Sigma y^2}{Ney}\right)^2}\right] \text{ which, for uniform pitch becomes}$$

$$f_t = \frac{3P}{AN(N-1)}\times\frac{e}{p}\times\left[1+\sqrt{1+\frac{(N-1)^2}{9}\left(\frac{p}{e}\right)^2}\right]$$

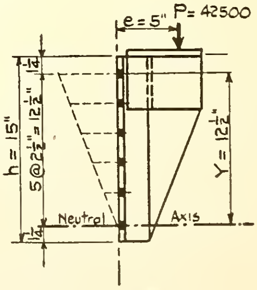
$$f_s = \frac{PeY}{4A\Sigma y^2}\sqrt{1+\left(\frac{4\Sigma y^2}{Ney}\right)^2} \text{ which, for uniform pitch becomes}$$

$$f_s = \frac{3P}{AN(N-1)}\times\frac{e}{p}\times\sqrt{1+\frac{(N-1)^2}{9}\left(\frac{p}{e}\right)^2}$$

Example: With same assumptions as in preceding example:

$$f_t = \frac{3\times 42{,}500}{0.442\times 12\times 11}\times\frac{5}{2.5}\times\left[1+\sqrt{1+\frac{121}{9}\times 0.25}\right] = 13{,}500\#/\square''$$

$$f_s = \frac{3\times 42{,}500}{0.442\times 12\times 11}\times\frac{5}{2.5}\times\sqrt{1+\frac{121}{9}\times 0.25} = 9{,}150\#/\square''$$



Osgood's Method

GENERAL: The rivets connecting vertical angles to gusset plate offer no unusual problems. In addition to their direct shear from "P", they must resist a turning force, caused by "P", acting around the center of gravity of the group. The total stress on extreme rivet is the square root of the sum of the squares of the two stresses.

BENDING AND DIRECT STRESS

DOUBLE ANGLE MEMBERS

COMPRESSION AND BENDING:

The general formula for this case is $A = \frac{P}{F} + \frac{Mc}{F_b r^2}$. By substituting co-efficients for $\frac{c}{F_b r^2}$ it becomes

$A_c = \frac{P}{F_c} + MK_c$, at center, and $A_e = \frac{P}{F_b} + M_eK_e$ at end, with $F_b = 18{,}000$.

Example:

Compression chord 5'-4" long; direct compression 70,000#; joist @ 16" cts. or ¼ points; trusses spaced 20'-0' cts.; roof load 50#□'. Joist load is 1.33×20×50 = 1,350#. Proper moment diagram below gives coefficients of 2.25*Pl* at center and 3.75 at end. Moments are therefore 16.2" /#s at center, and 27.0" /#s at end.

Assume 2-5×3×⅜*Ls;* with $r = 1.23$, $l \div r = (5.33 \times 12) \div 1.23 = 52$. Allowable $F_c = 15{,}000$.

Using co-efficients: $A_c = \frac{70{,}000}{15{,}000} + 16.2 \times .037 = 5.26\square''$ @ center.

$A_e = \frac{70{,}000}{18{,}000} + 27.0 \times .071 = 5.81\square''$ @ end.

TENSION AND BENDING:

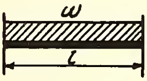
Example:

Assume joist as above carrying ceiling @ 20#/□' or 530# per joist. Direct tension in chord = 65,000#. Moments = 6,350"/#s at center, 10,600"/#s at end. Assume 2-5×3×5/16*Ls*. Net area 4.26□"; $S = 3.78$ in.³. From formula

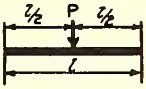
$F = \frac{P}{A} + \frac{M}{S}$, with max. mom. at end, $F = \frac{65{,}000}{4.26} + \frac{10{,}600}{3.78} = 18{,}050\#\square''$.

NOMENCLATURE

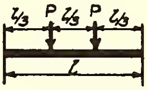
A = Gross area required.
A_c = Area required at center.
A_e = Area required at end.
F_c = Allow. unit comp. stress.
F_b = Allow. unit bend. or tension.
M = Bend. Mom. at center, kip in
M_e = Bend. Mom at end, kip in
l = Span, in feet.
w = Uniform load, per foot.



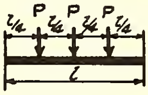
$M = 0.5wl^2$
$M_e = 1.0wl^2$



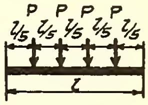
$M = 1.5Pl$
$M_e = 1.5Pl$



$M = 1.33Pl$
$M_e = 2.67Pl$



$M = 2.25Pl$
$M_e = 3.75Pl$



$M = 2.4Pl$
$M_e = 4.8Pl$

S = Section Modulus

DOUBLE ANGLE MEMBERS

r = Radius of gyration, Axis 1-1

SIZE OF ANGLES		AREA 2 ANGLES			Axis 1-1		K_c	K_e
		GROSS	NET 1 RIV. OUT					
			¾"	⅞"	S	r_1		
2½x2	3/16	1.62	1.30	1.24	.58	.79	.068	.155
	¼	2.12	1.68	1.62	.76	.78	.072	.156
	5/16	2.62	2.08	2.00	.94	.78	.074	.157
	⅜	3.10	2.44	2.34	1.10	.78	.078	.157
2½x2½	3/16	1.80	1.48	1.42	.60	.78	.063	.165
	¼	2.38	1.94	1.88	.78	.77	.067	.167
	5/16	2.94	2.40	2.32	.96	.76	.071	.169
	⅜	3.46	2.80	2.70	1.14	.75	.075	.172
3x2½	¼	2.62	2.18	2.12	1.12	.95	.056	.129
	5/16	3.24	2.70	2.62	1.38	.94	.058	.130
	⅜	3.84	3.18	3.08	1.62	.93	.062	.131
3x3	¼	2.88	2.44	2.38	1.16	.93	.054	.139
	5/16	3.56	3.12	3.04	1.42	.92	.057	.140
	⅜	4.22	3.56	3.46	1.66	.91	.059	.142
	7/16	4.86	4.10	3.98	1.90	.91	.061	.142
	½	5.50	4.62	4.50	2.20	.90	.064	.143
3½x2½	¼	2.88	2.44	2.38	1.50	1.12	.049	.106
	5/16	3.56	3.12	3.04	1.86	1.11	.051	.106
	⅜	4.22	3.56	3.46	2.20	1.10	.053	.107
	7/16	4.86	4.10	3.98	2.60	1.09	.055	.109
	½	5.50	4.62	4.50	2.80	1.09	.056	.109
3½x3	¼	3.12	2.68	2.62	1.56	1.11	.047	.111
	5/16	3.86	3.32	3.24	1.92	1.10	.049	.112
	⅜	4.60	3.94	3.84	2.20	1.09	.050	.113
	7/16	5.30	4.54	4.42	2.60	1.08	.052	.114
	½	6.00	5.12	5.00	3.00	1.07	.055	.115
4x3	¼	3.38	2.94	2.88	2.00	1.28	.042	.093
	5/16	4.18	3.64	3.56	2.40	1.27	.043	.094
	⅜	4.96	4.30	4.20	3.00	1.26	.045	.095
	7/16	5.74	4.98	4.86	3.40	1.25	.046	.096
	½	6.50	5.62	5.50	3.80	1.25	.048	.096
4x3½	5/16	4.50	4.06	4.00	2.60	1.26	.041	.010
	⅜	5.34	4.80	4.72	3.00	1.25	.043	.010
	7/16	6.18	5.52	5.42	3.40	1.24	.044	.010
	½	7.00	6.24	6.12	3.80	1.25	.046	.010
4x4	¼	3.88	3.44	3.38	2.00	1.23	.039	.103
	5/16	4.80	4.26	4.18	2.60	1.24	.041	.104
	⅜	5.72	5.06	4.96	3.00	1.23	.042	.105
	7/16	6.62	5.86	5.74	3.60	1.23	.043	.105
	½	7.50	6.62	6.50	4.00	1.22	.044	.106
	9/16	8.36	7.40	7.24	4.40	1.21	.046	.106
	⅝	9.22	8.12	7.96	4.80	1.20	.047	.107
5x3	5/16	4.80	4.26	4.18	3.80	1.61	.036	.071
	⅜	5.72	5.06	4.96	4.40	1.61	.036	.071
	7/16	6.62	5.86	5.74	5.20	1.60	.037	.071
	½	7.50	6.62	6.50	5.80	1.59	.038	.071
	9/16	8.36	7.40	7.24	6.40	1.58	.039	.072
	⅝	9.22	8.12	7.96	7.00	1.57	.041	.072
	11/16	10.06	8.86	8.68	7.80	1.56	.042	.073
	¾	10.88	9.56	9.38	8.40	1.55	.043	.073
5x3½	5/16	5.12	4.58	4.50	3.80	1.61	.034	.073
	⅜	6.10	5.44	5.34	4.60	1.60	.035	.073
	7/16	7.06	6.30	6.18	5.20	1.59	.036	.074
	½	8.00	7.12	7.00	6.00	1.58	.037	.074
	9/16	8.94	7.98	7.82	6.60	1.57	.038	.075
	⅝	9.84	8.74	8.58	7.40	1.56	.039	.075
	11/16	10.74	9.54	9.36	8.00	1.56	.039	.075
	¾	11.62	10.30	10.12	8.60	1.55	.040	.075
6x4	5/16	6.06	5.52	5.44	5.6	1.94	.029	.060
	⅜	7.22	6.56	6.46	6.6	1.93	.029	.061
	7/16	8.36	7.60	7.48	7.6	1.92	.030	.061
	½	9.50	8.62	8.50	8.6	1.91	.030	.061
	9/16	10.62	9.66	9.30	9.6	1.90	.031	.061
	⅝	11.72	10.62	10.46	10.6	1.90	.031	.061
	11/16	12.80	11.60	11.42	11.6	1.89	.032	.061
	¾	13.88	12.56	12.38	12.4	1.88	.033	.062
	13/16	14.94	13.52	13.32	13.4	1.87	.033	.062
	⅞	15.96	14.42	14.20	14.4	1.86	.034	.062
	15/16	17.00	15.36	15.12	15.2	1.86	.034	.062
	1	18.00	16.04	15.74	16.0	1.85	.035	.062
6x6	⅜	8.72	8.06	7.96	7.0	1.88	.026	.069
	7/16	10.12	9.36	9.24	8.2	1.87	.026	.069
	½	11.50	10.62	10.50	9.2	1.86	.027	.070
	9/16	12.86	11.88	11.74	10.2	1.85	.028	.070
	⅝	14.22	13.12	12.96	11.4	1.84	.028	.070
	11/16	15.56	14.36	14.18	12.4	1.83	.029	.070
	¾	16.88	15.56	15.40	13.4	1.83	.030	.070
	13/16	18.18	16.76	16.56	14.4	1.82	.030	.070
	⅞	19.46	17.92	17.70	15.2	1.81	.031	.071
	15/16	20.74	19.10	18.86	16.2	1.80	.032	.071
	1	22.00	20.24	20.00	17.2	1.80	.032	.071
7x4	⅜	7.98	7.32	7.22	8.8	2.27	.026	.050
	7/16	9.26	8.50	8.38	10.2	2.26	.026	.050
	½	10.50	9.62	9.50	11.6	2.25	.027	.050
	9/16	11.76	10.78	10.64	13.0	2.24	.027	.050
	⅝	12.98	11.88	11.72	14.2	2.24	.027	.050
	11/16	14.18	12.98	12.80	15.6	2.23	.028	.050
	¾	15.38	14.06	13.88	16.8	2.22	.028	.051
	13/16	16.56	15.14	14.94	18.0	2.21	.029	.051
	⅞	17.72	16.18	15.96	19.4	2.20	.029	.051
	15/16	18.88	17.24	17.00	20.6	2.19	.030	.051
	1	20.00	18.24	18.00	21.6	2.18	.030	.052
8x4	7/16	10.12	9.36	9.24	13.2	2.60	.023	.042
	½	11.50	10.62	10.50	15.0	2.59	.024	.043
	9/16	12.86	11.88	11.74	16.8	2.58	.024	.043
	⅝	14.22	13.12	12.96	18.4	2.56	.025	.043
	11/16	15.56	14.36	14.18	20.0	2.56	.025	.043
	¾	16.88	15.56	15.38	21.8	2.55	.025	.043
	13/16	18.18	16.76	16.56	23.4	2.54	.026	.043
	⅞	19.46	17.92	17.70	25.0	2.53	.026	.043
	15/16	20.74	19.10	18.86	26.6	2.52	.026	.043
	1	22.00	20.24	20.00	28.2	2.52	.027	.043
8x6	7/16	11.86	11.10	10.98	14.2	2.57	.021	.047
	½	13.50	12.62	12.50	16.0	2.56	.021	.047
	9/16	15.12	14.16	14.00	17.8	2.55	.021	.047
	⅝	16.72	15.62	15.46	19.8	2.54	.022	.047
	11/16	18.30	17.10	16.92	21.6	2.54	.022	.047
	¾	19.88	18.56	18.38	23.4	2.53	.022	.047
	13/16	21.44	20.02	19.82	25.0	2.52	.023	.047
	⅞	22.96	21.42	21.20	26.8	2.51	.023	.047
	15/16	24.50	22.86	22.62	28.6	2.50	.024	.047
	1	26.00	24.24	24.00	30.2	2.49	.024	.048
8x8	½	15.50	14.62	14.50	16.8	2.51	.019	.051
	9/16	17.36	16.40	16.24	18.6	2.50	.020	.051
	⅝	19.22	18.12	17.96	20.6	2.49	.020	.052
	11/16	21.06	19.86	19.68	22.4	2.48	.020	.052
	¾	22.88	21.56	21.38	24.4	2.47	.021	.052
	13/16	24.68	23.26	23.06	26.2	2.46	.021	.052
	⅞	26.46	24.92	24.70	28.0	2.45	.021	.053
	15/16	28.24	26.60	26.36	29.8	2.44	.022	.053
	1	30.00	28.24	28.00	31.6	2.44	.022	.053
	1 1/16	31.74			33.4	2.43	.022	.053
	1⅛	33.46	31.50	31.20	35.0	2.42	.023	

I = Moment of Inertia, in.^{4}
S = Section Modulus, in.^{3}
r = Radius of Gyration, in.

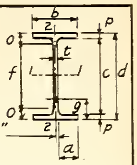
WIDE FLANGE BEAMS

PARALLEL FLANGE

A. I. S. C. SPECIFICATIONS

(OBSOLETE—For Reference Only)

M = Bending Moment, kip ft.
V = Max. Web Shear, kips
F_b = Unit Web Buckling, kips



h = ½ web + 1/16″

Moment, Shear and Buckling values are given for basic unit stress specifications of both 18000 and 20000 lbs. per sq. in.

SIZE	WT. PER FOOT	AREA SQ. IN.	Dimensions										Axis 1-1			Axis 2-2			M		V		Fb		WEIGHT OF BEAM INC. FIREPROOF'G		
			d	b	p	t	c	f	o	h	a	g	I	S	r	I	S	r	18000	20000	12000	13000	18000	20000	GYP.	CLAY TILE	STONE CONC.
6″	8.5	2.50	5⅞	4	3/16	3/16	5½	5	7/16	⅛	1⅞	1¾	14.8	5.07	2.43	1.89	0.96	0.87	8	8	12	13	15.0	15.0	30	45	70
	12	3.53	6	4	¼	¼	5½	5	½	3/16	1⅞	1¾	21.7	7.24	2.48	2.89	1.44	0.90	11	12	17	18	15.0	15.0	35	50	75
	16	4.72	6¼	4	⅜	¼	5½	5	⅝	3/16	1⅞	2	31.7	10.1	2.59	4.32	2.14	0.96	15	17	20	21	15.0	15.0	40	55	80
	15.5	4.59	6	6	¼	¼	5½	5	½	3/16	2⅞	1¾	30.1	10.0	2.56	9.19	3.06	1.42	15	17	17	19	15.0	15.0	40	55	80
	18	5.28	6⅛	6	5/16	¼	5½	5	9/16	3/16	2⅞	2	35.5	11.7	2.59	11.0	3.64	1.44	18	20	19	21	15.0	15.0	45	60	85
8″	10	2.95	7⅛	3⅞	3/16	3/16	7½	6⅞	½	⅛	1⅞	1¾	30.8	7.79	3.23	1.99	1.01	0.82	12	13	16	17	13.2	14.7	35	55	95
	13	3.83	8	4	¼	¼	7½	6⅞	9/16	3/16	1⅞	2	39.5	9.88	3.21	2.62	1.31	0.83	15	16	22	24	15.0	15.0	40	60	100
	15	4.43	8⅛	4	5/16	¼	7½	6⅞	⅝	3/16	1⅞	2	48.0	11.8	3.29	3.30	1.65	0.86	18	20	24	26	15.0	15.0	40	60	100
	17	5.00	8	5¼	5/16	¼	7⅜	6¾	⅝	3/16	2½	2¼	56.4	14.1	3.36	6.72	2.6	1.16	21	24	22	24	15.0	15.0	45	60	110
	19	5.59	8⅛	5¼	⅜	¼	7⅜	6¾	11/16	3/16	2½	2¼	64.7	16.0	3.40	7.87	3.0	1.19	24	27	24	26	15.0	15.0	50	65	115
	21	6.18	8¼	5¼	⅜	¼	7⅜	6¾	¾	3/16	2½	2¼	73.8	18.0	3.45	9.13	3.5	1.22	27	30	25	27	15.0	15.0	50	65	115
	24	7.06	7⅞	6½	⅜	¼	7⅛	6⅜	13/16	3/16	3⅛	2¼	82.5	20.8	3.42	18.2	5.6	1.61	31	35	23	25	15.0	15.0	50	70	130
	27	7.93	8	6½	7/16	5/16	7⅛	6⅜	⅞	3/16	3⅛	2¼	94.1	23.4	3.44	20.8	6.4	1.62	35	39	26	28	15.0	15.0	55	75	130
	31	9.12	8	8	7/16	5/16	7⅛	6⅜	13/16	¼	3⅞	2¼	109.7	27.4	3.47	37.0	9.2	2.01	41	46	28	30	15.0	15.0	60	80	155
	33	9.70	8	8	7/16	5/16	7⅛	6⅜	⅞	¼	3⅞	2¼	117.9	29.3	3.49	39.7	9.9	2.02	44	49	29	31	15.0	15.0	60	85	155
	35	10.30	8⅛	8	½	5/16	7⅛	6⅜	⅞	¼	3⅞	2¼	126.5	31.1	3.50	42.5	10.6	2.03	47	52	31	33	15.0	15.0	65	85	160
	40	11.76	8¼	8⅛	9/16	⅜	7⅛	6⅜	15/16	¼	3⅞	2¼	146.3	35.5	3.53	49.0	12.1	2.04	53	59	36	39	15.0	15.0	70	90	165
	48	14.11	8½	8⅛	11/16	7/16	7⅛	6⅜	1 1/16	¼	3⅞	2½	183.7	43.2	3.61	60.9	15.0	2.08	65	72	41	45	15.0	15.0	80	100	175
	58	17.06	8¾	8¼	13/16	½	7⅛	6⅜	1 3/16	5/16	3⅞	2½	227.3	52.0	3.65	74.9	18.2	2.10	78	87	54	58	15.0	15.0	90	110	190
	67	19.70	9	8¼	15/16	9/16	7⅛	6⅜	1 5/16	⅜	3⅞	2¾	271.8	60.4	3.71	88.6	21.4	2.12	91	101	62	67	15.0	15.0	100	120	200
10″	11.5	3.39	9⅞	4	3/16	3/16	9½	8⅞	½	3/16	1⅞	1¾	51.9	10.5	3.92	2.01	1.02	0.77	16	18	21	23	12.0	13.3	40	60	120
	15	4.40	10	4	¼	¼	9½	8⅞	9/16	3/16	1⅞	2	68.8	13.8	3.95	2.79	1.39	0.80	21	23	28	30	13.7	15.0	45	65	125
	17	4.98	10⅛	4	5/16	¼	9½	8⅞	⅝	3/16	1⅞	2	81.8	16.2	4.05	3.45	1.72	0.83	24	27	29	32	13.9	15.0	45	65	125
	19	5.61	10¼	4	⅜	¼	9½	8⅞	11/16	3/16	1⅞	2	96.2	18.8	4.14	4.19	2.08	0.86	28	31	31	33	14.1	15.0	50	70	130
	21	6.19	9⅞	5¾	5/16	¼	9¼	8½	11/16	3/16	2¾	2	106.3	21.5	4.14	9.7	3.4	1.25	32	36	28	31	14.0	15.0	50	75	145
	23	6.77	10	5¾	⅜	¼	9¼	8½	¾	3/16	2¾	2¼	120.6	24.1	4.22	11.3	3.9	1.29	36	40	29	31	14.0	15.0	50	75	150
	26	7.65	10⅛	5¾	7/16	¼	9¼	8½	13/16	3/16	2¾	2¼	139.7	27.6	4.27	13.4	4.6	1.32	41	46	32	34	14.4	15.0	55	80	150
	29	8.53	10¼	5¾	½	5/16	9¼	8½	⅞	¼	2¾	2¼	157.3	30.8	4.29	15.2	5.2	1.34	46	51	36	38	14.9	15.0	60	80	155
	33	9.71	9¾	8	7/16	5/16	8⅞	7⅞	15/16	¼	3⅞	2¼	170.9	35.0	4.20	36.5	9.2	1.94	53	58	34	37	15.0	15.0	65	90	185
	37	10.88	9⅞	8	½	5/16	8⅞	7⅞	1	¼	3⅞	2¼	196.9	39.9	4.25	42.2	10.6	1.97	60	67	36	39	15.0	15.0	70	95	185
	41	12.06	10	8	9/16	5/16	8⅞	7⅞	1 1/16	¼	3⅞	2½	222.4	44.5	4.29	47.7	11.9	1.99	67	74	39	43	15.0	15.0	70	100	190
	45	13.24	10⅛	8	⅝	⅜	8⅞	7⅞	1⅛	¼	3⅞	2½	248.6	49.1	4.33	53.2	13.3	2.00	74	82	43	46	15.0	15.0	75	100	195
	49	14.40	10	10	9/16	⅜	8⅞	7⅞	1 1/16	¼	4⅞	2½	272.9	54.6	4.35	93.0	18.6	2.54	82	91	41	44	15.0	15.0	80	105	225
	54	15.88	10⅛	10	⅝	⅜	8⅞	7⅞	1⅛	¼	4⅞	2½	305.7	60.4	4.39	103.9	20.7	2.56	91	101	45	48	15.0	15.0	85	110	230
	60	17.66	10¼	10⅛	11/16	7/16	8⅞	7⅞	1 3/16	5/16	4⅞	2½	343.7	67.1	4.41	116.5	23.1	2.57	101	112	51	55	15.0	15.0	90	115	235
	66	19.41	10⅜	10⅛	¾	7/16	8⅞	7⅞	1¼	5/16	4⅞	2½	382.5	73.7	4.44	129.2	25.5	2.58	110	123	57	62	15.0	15.0	100	125	240
	72	21.18	10½	10⅛	13/16	½	8⅞	7⅞	1 5/16	5/16	4⅞	2¾	420.7	80.1	4.46	141.8	27.9	2.59	120	133	64	70	15.0	15.0	105	130	245
	77	22.67	10⅝	10¼	⅞	9/16	8⅞	7⅞	1⅜	⅜	4⅞	2¾	457.2	86.1	4.49	153.4	30.1	2.60	129	143	68	74	15.0	15.0	110	135	250
12″	14	4.14	11⅞	4	¼	3/16	11⅜	10⅞	½	3/16	1⅞	1¾	88.2	14.8	4.61	2.25	1.13	0.74	22	25	29	31	11.3	12.6	45	70	145
	16.5	4.86	12	4	¼	¼	11½	10⅞	9/16	3/16	1⅞	2	105.3	17.5	4.65	2.79	1.39	0.76	26	29	33	36	12.4	13.8	45	70	145
	19	5.62	12⅛	4	5/16	¼	11½	10⅞	⅝	3/16	1⅞	2	130.1	21.4	4.81	3.67	1.83	0.81	32	36	35	38	12.6	14.0	50	75	150
	22	6.47	12¼	4	7/16	¼	11⅜	10¾	¾	3/16	1⅞	2	155.7	25.3	4.91	4.55	2.26	0.84	38	42	38	42	13.1	14.6	55	80	155
	25	7.39	11⅞	6½	⅜	¼	11⅛	10⅜	¾	3/16	3⅛	2¼	183.4	30.9	4.98	14.5	4.5	1.40	46	52	34	37	12.8	14.2	60	80	170
	28	8.23	12	6½	7/16	¼	11⅛	10⅜	13/16	3/16	3⅛	2¼	213.5	35.6	5.09	17.5	5.4	1.46	53	59	35	37	12.7	14.1	60	85	175
	32	9.41	12⅛	6½	½	5/16	11⅛	10⅜	⅞	3/16	3⅛	2¼	246.8	40.7	5.12	20.6	6.3	1.48	61	68	40	43	13.6	15.0	65	90	175
	36	10.59	12¼	6⅝	9/16	5/16	11⅛	10⅜	15/16	¼	3⅛	2¼	280.8	45.9	5.15	23.7	7.2	1.50	69	77	45	49	14.2	15.0	70	95	180
	40	11.77	12	8	½	5/16	10⅞	9¾	1⅛	¼	3⅞	2½	310.1	51.9	5.13	44.1	11.0	1.94	78	86	42	46	14.1	15.0	75	100	215
	45	13.24	12	8	9/16	⅜	10⅞	9¾	1 3/16	¼	3⅞	2½	350.8	58.2	5.15	50.0	12.4	1.94	87	97	49	53	14.8	15.0	80	105	220
	50	14.71	12¼	8⅛	⅝	⅜	10⅞	9¾	1¼	¼	3⅞	2½	394.5	64.7	5.18	56.4	14.0	1.96	97	108	54	59	15.0	15.0	85	110	225
	53	15.59	12	10	9/16	⅜	10⅞	9¾	1 3/16	¼	4⅞	2½	426.2	70.7	5.23	96.1	19.2	2.48	106	118	50	54	15.0	15.0	90	115	255
	58	17.06	12¼	10	⅝	⅜	10⅞	9¾	1¼	¼	4⅞	2½	476.1	78.1	5.28	107.4	21.4	2.51	117	130	53	57	15.0	15.0	95	120	260
	64	18.83	12¼	10	11/16	7/16	10⅞	9¾	1 5/16	¼	4⅞	2½	528.3	85.8	5.29	119.0	23.7	2.51	129	143	60	65	15.0	15.0	100	130	270
	65	19.11	12⅛	12	⅝	⅜	10⅞	9¾	1 3/16	¼	5¾	2½	533.4	88.0	5.28	174.6	29.1	3.02	132	147	57	61	15.0	15.0	105	135	300
	72	21.16	12¼	12	11/16	7/16	10⅞	9¾	1¼	5/16	5¾	2½	597.4	97.5	5.31	195.3	32.4	3.04	146	162	63	68	15.0	15.0	110	140	305
	79	23.22	12⅜	12⅛	¾	½	10⅞	9¾	1 5/16	5/16	5¾	2¾	663.0	107.1	5.34	216.4	35.8	3.05	161	178	70	76	15.0	15.0	115	145	310
	85	24.98	12½	12⅛	13/16	½	10⅞	9¾	1⅜	5/16	5¾	2¾	723.3	115.7	5.38	235.5	38.9	3.07	174	193	74	80	15.0	15.0	120	155	320
	92	27.06	12⅝	12⅛	⅞	9/16	10⅞	9¾	1 7/16	⅜	5¾	2¾	788.9	125.0	5.40	256.4	42.2	3.08	188	208	83	89	15.0	15.0	125	160	325
	99	29.09	12¾	12¼	15/16	⅝	10⅞	9¾	1½	⅜	5¾	2¾	858.5	134.7	5.43	278.2	45.7	3.09	202	224	89	96	15.0	15.0	130	165	330
	106	31.19	12⅞	12¼	1	⅝	10⅞	9¾	1 9/16	⅜	5¾	3	930.7	144.5	5.46	300.9	49.2	3.11	217	241	96	104	15.0	15.0	135	170	335
	120	35.31	13⅛	12⅜	1⅛	¾	10⅞	9¾	1 11/16	7/16	5¾	3	1071.7	163.4	5.51	345.1	56.0	3.13	245	272	112	121	15.0	15.0	150	185	350
14″	30	8.81	13⅞	6¾	⅜	5/16	13⅛	12⅛	⅞	3/16	3¼	2¼	289.6	41.8	5.73	17.5	5.2	1.41	63	70	45	49	12.5	13.9	65	95	215
	34	10.00	14	6¾	7/16	5/16	13⅛	12⅛	15/16	¼	3¼	2¼	339.2	48.5	5.83	21.3	6.3	1.46	73	81	48	52	12.9	14.3	70	100	220
	38	11.17	14⅛	6¾	½	5/16	13⅛	12⅛	1	¼	3¼	2¼	385.3	54.6	5.87	24.6	7.3	1.49	82	91	53	57	13.4	14.9	75	105	220
	42	12.34	14¼	6¾	9/16	⅜	13⅛	12⅛	1 1/16	¼	3¼	2¼	432.2	60.7	5.92	28.1	8.3	1.51	91	101	58	63	13.9	15.0	80	110	225
	43	12.65	13⅝	8	½	5/16	12⅝	11⅜	1⅛	¼	3⅞	2½	429.0	62.7	5.82	45.1	11.3	1.89	94	104	51	55	13.6	15.0	80	115	245
	48	14.11	13¾	8	9/16	⅜	12⅝	11⅜	1 3/16	¼	3⅞	2½	484.9	70.2	5.86	51.3	12.8	1.91	105	117	56	61	14.1	15.0	85	120	250
	53	15.59	14	8	11/16	⅜	12⅝	11⅜	1¼	¼	3⅞	2½	542.1	77.8	5.90	57.5	14.3	1.92	117	130	62	67	14.6	15.0	90	125	255
	58	17.06	14	8⅛	11/16	7/16	12⅝	11⅜	1 5/16	¼	3⅞	2½	597.9	85.0	5.92	63.7	15.7	1.93	128	142	69	74	15.0	15.0	95	130	260
	61	17.94	13⅞	10	⅝	⅜	12⅝	11⅜	1¼	¼	4¾	2½	641.5	92.2	5.98	107.3	21.5	2.45	138	154	63	68	14.7	15.0	100	135	295
	68	20.00	14	10	11/16	7/16	12⅝	11⅜	1 5/16	5/16	4¾	2½	724.1	103.0	6.02	121.2	24.1	2.46	155	172	71	76	15.0	15.0	110	140	305
	74	21.76	14¼	10⅛	13/16	7/16	12⅝	11⅜	1⅜	5/16	4¾	2¾	796.8	112.3	6.05	133.5	26.5	2.48	169	187	77	82	15.0	15.0	115	145	310
	78	22.94	14	12	11/16	7/16	12⅝	11⅜	1 5/16	5/16	5¾	2½	851.2	121.1	6.09	206.9	34.5	3.00	182	202	72	78	15.0	15.0	120	155	345
	84	24.71	14⅛	12	¾	7/16	12⅝	11⅜	1⅜	5/16	5¾	2¾	928.4	130.9	6.13	225.5	37.5	3.02	196	218	77	82	15.0	15.0	125	160	350
	87	25.56	14	14½	11/16	7/16	12⅝	11⅜	1 5/16	5/16	7	2½	966.9	138.1	6.15	349.7	48.2	3.70	207	230	71	77	15.0	15.0	130	165	390
	95	27.94	14⅛	14½	¾	½	12⅝	11⅜	1⅜	5/16	7	2¾	1063.5	150.6	6.17	383.7	52.8	3.71	226	251	79	86	15.0	15.0	140	175	395
	103	30.26	14¼	14⅝	13/16	½	12⅝	11⅜	1 7/16	5/16	7	2¾	1165.8	163.6	6.21	419.7	57.6	3.72	245	273	85	91	15.0	15.0	150	180	405
	111	32.65	14⅜	14⅝	⅞	9/16	12⅝	11⅜	1½	⅜	7	2¾	1266.5	176.3	6.23	454.9	62.2	3.73	264	294	93	101	15.0	15.0	155	190	410
	119	34.99	14½	14⅝	15/16	9/16	12⅝	11⅜	1 9/16	⅜	7	2¾	1373.1	189.4	6.26	491.8	67.1	3.75	284	315	99	107	15.0	15.0	165	205	420
	127	37.33	14⅝	14¾	1	⅝	12⅝	11⅜	1⅝	⅜	7	3	1476.7	202.0	6.29	527.6	71.8	3.76	303	337	107	116	15.0	15.0	175	215	430
	136	39.98	14¾	14¾	1 1/16	11/16	12⅝	11⅜	1 11/16	7/16	7	3	1593.0	216.0	6.31	567.7	77.0	3.77	324	360	117	126	15.0	15.0	180	220	435
	142	41.85	14¾	15½	1 1/16	11/16	12⅝	11⅜	1 11/16	7/16	7⅜	3	1672.2	226.7	6.32	660.1	85.2	3.97	340	378	120	130	15.0	15.0	185	225	440
	150	44.08	14⅞	15½	1⅛	11/16	12⅝	11⅜	1¾	7/16	7⅜	3	1786.9	240.2	6.37	702.5	90.6	3.99	360	401	124	134	15.0	15.0	195	235	450

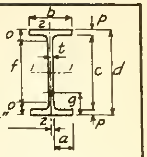
I = Moment of Inertia, in.^{4}
S = Section Modulus, in.^{3}
r = Radius of Gyration, in.

WIDE FLANGE BEAMS

PARALLEL FLANGE

A. I. S. C. SPECIFICATIONS

M = Bending Moment, kip ft.
V = Max. Web Shear, kips
F_b = Unit Web Buckling, kips



h = ½ web + 1/16"

(OBSOLETE—For Reference Only)

Moment, Shear and Buckling values are given for basic unit stress specifications of both 18000 and 20000 lbs. per sq. in.

SIZE	WT. PER FOOT	AREA SQ. IN.	Dimensions										Axis 1-1			Axis 2-2			M		V		Fb		WEIGHT OF BEAM INC. FIREPROOF'G		
			d	b	p	t	c	f	o	h	a	g	I	S	r	I	S	r	18000	20000	12000	13000	18000	20000	Gyp.	Clay Tile	Stone Conc.
16"	36	10.59	15⅞	7	7/16	5/16	15	14	15/16	¼	3⅜	2¼	446.3	56.3	6.49	22.1	6.3	1.45	84	94	57	62	12.2	13.6	75	105	240
	40	11.77	16	7	½	5/16	15	14	1	¼	3⅜	2¼	515.5	64.4	6.62	26.5	7.6	1.50	97	107	59	64	12.4	13.8	80	110	245
	45	13.24	16⅛	7	9/16	⅜	15	14	1 1/16	¼	3⅜	2¼	583.3	72.4	6.64	30.5	8.7	1.52	109	121	67	72	13.2	14.7	85	115	250
	50	14.70	16¼	7⅛	⅝	⅜	15	14	1⅛	¼	3⅜	2½	655.4	80.7	6.68	34.8	9.8	1.54	121	135	74	80	13.8	15.0	90	120	255
	58	17.04	15⅞	8½	⅝	7/16	14⅝	13⅜	1¼	5/16	4	2½	746.4	94.1	6.62	60.5	14.3	1.88	141	157	78	84	14.4	15.0	100	135	285
	64	18.80	16	8½	11/16	7/16	14⅝	13⅜	1 5/16	5/16	4	2½	833.8	104.2	6.66	68.4	16.1	1.91	156	174	85	92	14.8	15.0	105	140	290
	71	20.86	16⅛	8½	13/16	½	14⅝	13⅜	1⅜	5/16	4	2¾	936.9	115.9	6.70	77.9	18.2	1.93	174	193	94	102	15.0	15.0	110	145	295
	78	22.92	16⅜	8⅝	⅞	9/16	14⅝	13⅜	1½	5/16	4	2¾	1042.6	127.8	6.74	87.5	20.4	1.95	192	213	104	112	15.0	15.0	115	150	300
	88	25.87	16⅛	11½	13/16	½	14⅝	13⅛	1½	5/16	5½	2¾	1222.6	151.3	6.87	185.2	32.2	2.67	227	252	98	106	15.0	15.0	135	170	390
	96	28.22	16⅜	11½	⅞	9/16	14⅝	13⅛	1⅝	⅜	5½	2¾	1355.1	166.1	6.93	207.2	35.9	2.71	249	277	105	114	15.0	15.0	145	180	400
	105	30.87	16½	11⅝	13/16	⅝	14⅝	13⅛	1 11/16	⅜	5½	3	1497.5	181.7	6.96	230.7	39.8	2.73	273	303	116	125	15.0	15.0	155	190	410
	114	33.51	16⅝	11⅝	1 1/16	⅝	14⅝	13⅛	1¾	⅜	5½	3	1642.6	197.4	7.00	254.6	43.8	2.76	296	329	126	136	15.0	15.0	165	200	420
18"	47	13.81	17⅞	7½	½	⅜	16⅞	15⅞	1	¼	3⅝	2¼	736.4	82.3	7.30	33.5	9.0	1.56	123	137	75	81	12.5	13.9	90	120	295
	50	14.71	18	7½	9/16	⅜	16⅞	15⅞	1 1/16	¼	3⅝	2¼	800.6	89.0	7.38	37.2	9.9	1.59	134	148	77	84	12.7	14.1	95	125	300
	55	16.19	18⅛	7½	⅝	⅜	16⅞	15⅞	1⅛	¼	3⅝	2½	889.9	98.2	7.41	42.0	11.1	1.61	147	164	85	92	13.2	14.7	100	130	305
	64	18.80	17⅞	8¾	11/16	7/16	16½	15⅜	1¼	¼	4⅛	2½	1045.8	117.0	7.46	70.3	16.1	1.93	176	195	86	94	13.6	15.0	110	140	335
	70	20.56	18	8¾	¾	7/16	16½	15⅜	1 5/16	5/16	4⅛	2¾	1153.9	128.2	7.49	78.5	17.9	1.95	192	214	95	102	14.1	15.0	115	150	340
	77	22.63	18⅛	8¾	13/16	½	16½	15⅜	1⅜	5/16	4⅛	2¾	1286.8	141.7	7.54	88.6	20.2	1.98	213	236	104	112	14.5	15.0	120	155	350
	85	24.97	18⅜	8⅞	15/16	9/16	16½	15⅜	1½	5/16	4⅛	2¾	1429.9	156.1	7.57	99.4	22.5	2.00	234	260	116	125	15.0	15.0	130	165	360
	96	28.22	18⅛	11¾	13/16	½	16½	15⅛	1½	5/16	5⅝	2¾	1674.7	184.4	7.70	206.8	35.2	2.71	277	307	112	121	14.9	15.0	145	180	425
	105	30.86	18⅜	11¾	15/16	9/16	16½	15⅛	1⅝	⅜	5⅝	2¾	1852.5	202.2	7.75	231.0	39.2	2.73	303	337	122	132	15.0	15.0	155	190	435
	114	33.51	18½	11⅞	1	⅝	16½	15⅛	1 11/16	⅜	5⅝	3	2033.8	220.1	7.79	255.6	43.2	2.76	330	367	132	143	15.0	15.0	165	200	445
	124	36.45	18⅝	11⅞	1 1/16	11/16	16½	15⅛	1¾	⅜	5⅝	3	2227.1	239.0	7.82	281.9	47.4	2.78	359	398	146	158	15.0	15.0	175	210	455
21"	59	17.36	20⅞	8¼	9/16	⅜	19¾	18⅝	1⅛	¼	4	2½	1246.8	119.3	8.47	49.2	12.0	1.68	179	199	98	106	12.2	13.5	105	145	350
	63	18.52	21	8¼	⅝	7/16	19¾	18⅝	1 3/16	5/16	4	2½	1343.6	128.0	8.52	53.8	13.0	1.70	192	213	103	112	12.5	13.9	110	150	355
	68	20.02	21⅛	8¼	11/16	7/16	19¾	18⅝	1¼	5/16	4	2½	1478.3	139.9	8.59	60.4	14.6	1.74	210	233	109	118	12.8	14.3	115	155	360
	73	21.46	21¼	8¼	¾	½	19¾	18⅝	1 5/16	5/16	4	2½	1600.3	150.7	8.64	66.2	16.0	1.76	226	251	116	126	13.2	14.7	120	160	365
	82	24.10	20⅞	9	13/16	½	19¼	18	1 7/16	5/16	4¼	2¾	1752.4	168.0	8.53	89.6	20.0	1.93	252	280	125	135	13.9	15.0	135	170	390
	89	26.15	21	9	⅞	9/16	19¼	18	1½	⅜	4¼	2¾	1919.2	182.8	8.57	99.4	22.1	1.95	274	305	135	147	14.3	15.0	140	175	395
	96	28.21	21⅛	9	15/16	9/16	19¼	18	1 9/16	⅜	4¼	2¾	2088.9	197.6	8.60	109.3	24.2	1.97	296	329	146	158	14.7	15.0	145	180	400
	103	30.27	21¼	9⅛	1	⅝	19¼	18	1⅝	⅜	4¼	3	2268.0	213.1	8.66	119.9	26.4	1.99	320	355	155	168	15.0	15.0	150	185	405
	112	32.93	21	13	⅞	9/16	19¼	17¾	1⅝	5/16	6¼	3	2620.6	249.6	8.92	289.7	44.6	2.96	374	416	133	144	14.2	15.0	165	205	520
	122	35.85	21⅛	13	15/16	9/16	19¼	17¾	1 11/16	⅜	6¼	3	2883.2	272.5	8.97	322.1	49.4	3.00	409	454	144	156	14.6	15.0	175	215	530
	132	38.81	21¼	13⅛	1	⅝	19¼	17¾	1¾	⅜	6¼	3	3141.6	294.8	9.00	353.8	54.1	3.02	442	491	156	170	15.0	15.0	185	225	540
	142	41.76	21½	13⅛	1⅛	11/16	19¼	17¾	1⅞	7/16	6¼	3	3403.1	317.2	9.03	385.9	58.8	3.04	476	529	170	184	15.0	15.0	195	235	550
24"	74	21.77	23⅞	9	11/16	7/16	22½	21⅜	1¼	5/16	4¼	2½	2033.8	170.4	9.67	73.8	16.5	1.84	256	284	123	133	11.9	13.2	130	165	425
	80	23.54	24	9	¾	½	22½	21⅜	1 5/16	5/16	4¼	2½	2229.7	185.8	9.73	82.4	18.3	1.87	279	310	131	142	12.3	13.7	135	170	430
	87	25.58	24⅛	9	13/16	½	22½	21⅜	1⅜	5/16	4¼	2¾	2467.8	204.3	9.82	92.9	20.6	1.91	306	341	139	151	12.7	14.1	140	175	435
	94	27.63	24¼	9	⅞	9/16	22½	21⅜	1 7/16	5/16	4¼	2¾	2683.0	220.9	9.85	102.2	22.6	1.92	331	368	150	163	13.2	14.6	150	180	440
	100	29.43	24	12	¾	½	22⅜	20⅞	1 9/16	5/16	5¾	2¾	2987.3	248.9	10.08	203.5	33.9	2.63	373	415	135	146	12.5	13.9	160	200	535
	110	32.36	24⅛	12	⅞	½	22⅜	20⅞	1⅝	5/16	5¾	2¾	3315.0	274.4	10.12	229.1	38.0	2.66	412	457	148	160	13.1	14.5	170	210	545
	120	35.29	24¼	12⅛	15/16	9/16	22⅜	20⅞	1 11/16	⅜	5¾	3	3635.3	299.1	10.15	254.0	42.0	2.68	449	499	162	176	13.7	15.0	180	220	555
	130	38.21	24¼	14	⅞	9/16	22⅜	20¾	1¾	⅜	6¾	3	4009.5	330.7	10.24	375.2	53.6	3.13	496	551	164	178	13.8	15.0	190	235	620
	140	41.16	24⅜	14	1	⅝	22⅜	20¾	1 13/16	⅜	6¾	3	4376.1	358.6	10.31	414.5	59.1	3.17	538	598	174	188	14.1	15.0	200	245	630
	150	44.10	24½	14⅛	1 1/16	⅝	22⅜	20¾	1⅞	⅜	6¾	3¼	4733.5	385.5	10.36	452.5	64.3	3.20	578	643	185	201	14.3	15.0	210	255	640
	160	47.04	24¾	14⅛	1⅛	11/16	22⅜	20¾	2	⅜	6¾	3¼	5110.3	413.5	10.42	492.6	69.9	3.23	620	689	195	211	14.6	15.0	220	265	650
27"	91	26.77	26⅞	10	11/16	½	25⅜	24	1 7/16	5/16	4¾	2¾	3129.2	233.2	10.81	109.0	21.8	2.02	350	389	156	169	11.9	13.2	150	195	515
	98	28.82	27	10	13/16	½	25⅜	24	1½	5/16	4¾	2¾	3446.5	255.3	10.94	122.9	24.6	2.07	383	426	162	175	12.1	13.4	155	200	520
	106	31.17	27⅛	10	⅞	9/16	25⅜	24	1 9/16	⅜	4¾	2¾	3761.2	277.2	10.98	136.1	27.1	2.09	416	462	174	189	12.6	14.0	165	210	530
	114	33.53	27¼	10⅛	15/16	9/16	25⅜	24	1⅝	⅜	4¾	2¾	4080.5	299.2	11.03	149.6	29.7	2.11	449	499	187	202	13.0	14.5	170	215	535
	145	42.68	26⅞	14	1	⅝	24⅞	23	1 15/16	⅜	6¾	3¼	5414.3	402.9	11.26	406.9	58.3	3.09	604	672	194	210	13.5	15.0	210	255	690
	154	45.30	27	14	1 1/16	⅝	24⅞	23	2	⅜	6¾	3¼	5775.8	427.8	11.29	437.6	62.5	3.11	642	713	206	223	13.8	15.0	220	265	700
	163	47.93	27⅛	14	1⅛	11/16	24⅞	23	2 1/16	7/16	6¾	3¼	6141.5	452.9	11.32	468.7	66.8	3.13	679	755	218	236	14.1	15.0	230	275	710
	177	52.10	27¼	14⅛	1 3/16	¾	24⅞	23	2⅛	7/16	6¾	3¼	6728.6	492.8	11.36	518.9	73.7	3.16	739	821	238	257	14.5	15.0	245	290	725
30"	108	31.77	29⅞	10½	¾	9/16	28¼	26⅞	1½	⅜	5	2¾	4461.0	299.2	11.85	135.1	25.8	2.06	449	499	196	212	12.1	13.4	175	220	575
	116	34.13	30	10½	⅞	9/16	28¼	26⅞	1 9/16	⅜	5	2¾	4919.1	327.9	12.00	153.2	29.2	2.12	492	547	203	220	12.2	13.6	180	225	580
	124	36.45	30⅛	10½	15/16	⅝	28¼	26⅞	1⅝	⅜	5	3	5347.1	354.6	12.11	169.7	32.3	2.16	532	591	212	229	12.5	13.8	190	235	590
	132	38.83	30¼	10½	1	⅝	28¼	26⅞	1 11/16	⅜	5	3	5753.1	379.7	12.17	185.0	35.1	2.18	570	633	224	242	12.8	14.2	200	245	600
	172	50.65	29⅞	15	1 1/16	11/16	27¾	25¾	2 1/16	⅜	7⅛	3¼	7891.5	528.2	12.48	550.1	73.4	3.30	792	880	235	254	13.4	14.8	240	290	770
	180	52.89	30	15	1⅛	11/16	27¾	25¾	2⅛	7/16	7⅛	3¼	8328.2	555.2	12.55	585.6	78.1	3.33	833	925	241	261	13.5	15.0	250	300	780
	190	55.90	30⅛	15	1 3/16	¾	27¾	25¾	2 3/16	7/16	7⅛	3½	8825.9	586.1	12.57	624.6	83.1	3.34	879	977	257	278	13.9	15.0	260	310	790
	200	58.76	30¼	15⅛	1¼	¾	27¾	25¾	2¼	7/16	7⅛	3½	9340.5	617.6	12.61	665.7	88.3	3.37	926	1029	269	291	14.1	15.0	270	320	800
	210	61.78	30⅜	15⅛	1 5/16	13/16	27¾	25¾	2 5/16	7/16	7⅛	3½	9872.4	649.9	12.64	707.9	93.7	3.38	975	1083	283	306	14.3	15.0	280	330	810
33"	125	36.78	33	11½	13/16	9/16	31⅜	29¾	1⅝	⅜	5½	2¾	6354.7	385.1	13.14	188.2	32.7	2.26	578	642	226	245	11.6	12.8	200	250	670
	132	38.84	33⅛	11½	⅞	⅝	31⅜	29¾	1 11/16	⅜	5½	3	6856.8	413.7	13.29	207.8	36.1	2.31	621	690	231	250	11.7	13.0	210	260	680
	141	41.51	33¼	11½	15/16	⅝	31⅜	29¾	1¾	⅜	5½	3	7442.2	446.8	13.39	229.7	39.8	2.35	670	745	242	262	12.0	13.3	220	270	690
	152	44.71	33½	11⅝	1 1/16	⅝	31⅜	29¾	1⅞	⅜	5½	3	8147.6	486.4	13.50	256.1	44.3	2.39	730	811	255	277	12.3	13.7	230	280	700
	200	58.79	33	15¾	1⅛	¾	30¾	28⅝	2 3/16	7/16	7½	3½	11048.2	669.6	13.71	691.7	87.8	3.43	1004	1116	283	307	13.3	14.8	280	330	930
	210	61.78	33⅛	15¾	1 3/16	¾	30¾	28⅝	2¼	7/16	7½	3½	11664.5	704.4	13.74	735.6	93.2	3.45	1057	1174	297	322	13.6	15.0	290	340	940
	220	64.73	33¼	15¾	1¼	13/16	30¾	28⅝	2 5/16	7/16	7½	3½	12312.1	740.6	13.79	782.4	99.0	3.48	1111	1234	309	335	13.8	15.0	300	350	950
	240	70.52	33½	15⅞	1⅜	⅞	30¾	28⅝	2 7/16	½	7½	3¾	13585.1	811.1	13.88	874.3	110.2	3.52	1217	1352	334	362	14.2	15.0	320	370	970
36"	150	44.16	35⅞	12	15/16	⅝	34	32¼	1 13/16	⅜	5⅝	3	9012.1	502.9	14.29	250.4	41.8	2.38	754	838	269	291	11.6	12.9	230	280	780
	160	47.09	36	12	1	11/16	34	32¼	1⅞	⅜	5⅝	3	9738.8	541.0	14.38	275.4	45.9	2.42	812	902	282	306	12.0	13.3	240	290	790
	170	49.98	36⅛	12	1⅛	11/16	34	32¼	1 15/16	7/16	5⅝	3¼	10470.0	579.1	14.47	300.6	50.0	2.45	869	965	295	320	12.2	13.6	250	300	800
	182	53.54	36⅜	12⅛	1 3/16	¾	34	32¼	2 1/16	7/16	5⅝	3¼	11281.5	621.2	14.52	327.7	54.3	2.47	932	1035	316	342	12.7	14.1	260	310	810
	194	57.11	36½	12⅛	1¼	13/16	34	32¼	2⅛	7/16	5⅝	3¼	12103.4	663.6	14.56	355.4	58.7	2.49	995	1106	337	365	13.1	14.6	275	325	825
	230	67.73	35⅞	16½	1¼	¾	33⅜	31⅛	2⅜	7/16	7⅞	3½	14988.4	835.5	14.88	870.9	105.7	3.59	1253	1393	329	357	13.2	14.6	315	370	1020
	240	70.60	36	16½	1 5/16	13/16	33⅜	31⅛	2 7/16	½	7⅞	3¾	15724.0	873.6	14.92	920.1	111.5	3.61	1310	1456	341	370	13.4	14.8	325	380	1030
	250	73.49	36⅛	16½	1⅜	13/16	33⅜	31⅛	2½	½	7⅞	3¾	16465.9	911.7	14.97	969.6	117.4	3.63	1368	1520	353	383	13.6	15.0	335	390	1040
	260	76.56	36¼	16½	1 7/16	⅞	33⅜	31⅛	2 9/16	½	7⅞	3¾	17233.8	951.1	15.00	1020.6	123.3	3.65	1427	1585	367	398	13.8	15.0	345	400	1050
	280	82.32	36½	16⅝	1 9/16	⅞	33⅜	31⅛	2 11/16	½	7⅞	4	18819.3	1031.2	15.12	1127.5	135.9	3.70	1547	1719	388	420	14.0	15.0	365	420	1070
	300	88.17	36¾	16⅝	1 11/16	15/16	33⅜	31⅛	2 13/16	9/16	7⅞	4	20290.2	1105.1	15.17	1225.2	147.1	3.73	1658	1842	416	451	14.4	15.0	385	440	1090

I = Moment of Inertia.
S = Section Modulus.
r = Radius of Gyration.
M = Bending Moment,
kip ft. lbs.

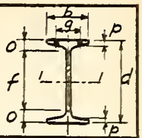
AMERICAN STANDARD BEAMS

A. I. S. C. SPECIFICATIONS

(OBSOLETE—For Reference Only)

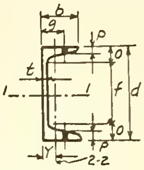
* Denotes Illinois Special Light Section.

V = Max. Web Shear, kips.
F = Total Web Buckling, kips.
F_b = Unit Web Buckling.
R = Value ¾″ Web Rivet.



SIZE	WT. PER FOOT	AREA SQ. IN.	Dimensions							Axis 1-1			Axis 2-2			M	V	F	F_b	R	MAX. FLG. RIV.	WEIGHT OF BEAM INC. FIREPROOF'G		
			d	b	p	t	f	o	g	I	S	r	I	S	r							GYP.	CLAY TILE	CONC.
3″	5.7	1.64	3	2 5/16	5/16	3/16	1¾	⅝	1½	2.5	1.7	1.23	0.46	0.40	0.53	2.6	6.1	7.7	15000	3830	⅜			
	6.5	1.88	3	2 7/16	5/16	¼	1¾	⅝	1½	2.7	1.8	1.19	0.51	0.43	0.52	2.7	9.0	11	15000	5650	⅜			
	7.5	2.17	3	2½	5/16	⅜	1¾	⅝	1½	2.9	1.9	1.15	0.59	0.47	0.52	2.9	13.0	16	15000	7850	⅜			
4″	7.7	2.21	4	2 11/16	5/16	3/16	2¾	⅝	1½	6.0	3.0	1.64	0.77	0.58	0.59	4.5	9.1	11	15000	4280	½			
	8.5	2.46	4	2¾	5/16	¼	2¾	⅝	1½	6.3	3.2	1.60	0.83	0.61	0.58	4.8	12.0	15	15000	5690	½			
	9.5	2.76	4	2 13/16	5/16	5/16	2¾	⅝	1½	6.7	3.3	1.56	0.91	0.65	0.58	5.0	16.0	19	15000	7340	½			
	10.5	3.05	4	2⅞	5/16	7/16	2¾	⅝	1½	7.1	3.5	1.52	1.0	0.70	0.57	5.3	19.0	24	15000	9000	½			
5″	10.0	2.87	5	3	⅜	3/16	3½	¾	1¾	12.1	4.8	2.05	1.2	0.82	0.65	7.2	13	16	15000	4730	½			
	12.25	3.56	5	3⅛	⅜	⅜	3½	¾	1¾	13.5	5.4	1.95	1.4	0.91	0.63	8.1	21	26	15000	7810	½			
	14.75	4.29	5	3 5/16	⅜	½	3½	¾	1¾	15.0	6.0	1.87	1.7	1.0	0.63	9.0	30	37	15000	11100	½			
6″	12.5	3.61	6	3 5/16	⅜	¼	4½	¾	2	21.8	7.3	2.46	1.8	1.1	0.72	11	17	20	14672	5180	⅝	30	45	70
	14.75	4.29	6	3 7/16	⅜	⅜	4½	¾	2	23.8	7.9	2.36	2.1	1.2	0.69	12	25	31	15000	7720	⅝	30	45	70
	17.25	5.02	6	3 9/16	⅜	7/16	4½	¾	2	26.0	8.7	2.28	2.3	1.3	0.68	13	33	42	15000	10460	⅝	35	50	75
7″	15.3	4.43	7	3 11/16	⅜	¼	5¼	⅞	2¼	36.2	10.4	2.86	2.7	1.5	0.78	16	21	25	14271	5630	⅝	35	55	90
	17.5	5.09	7	3¾	⅜	⅜	5¼	⅞	2¼	38.9	11.1	2.77	2.9	1.6	0.76	17	29	36	15000	7760	⅝	40	60	95
	20.0	5.83	7	3⅞	⅜	7/16	5¼	⅞	2¼	41.9	12.0	2.68	3.1	1.6	0.74	18	38	47	15000	10100	⅝	40	60	95
8″	18.4	5.34	8	4	7/16	¼	6¼	⅞	2¼	56.9	14.2	3.26	3.8	1.9	0.84	21	26	30	13925	6080	¾	40	60	105
	20.5	5.97	8	4 1/16	7/16	⅜	6¼	⅞	2¼	60.2	15.1	3.18	4.0	2.0	0.82	23	34	42	15000	7850	¾	40	60	105
	23.0	6.71	8	4 3/16	7/16	7/16	6¼	⅞	2¼	64.2	16.0	3.09	4.4	2.1	0.81	24	42	53	15000	9920	¾	45	65	110
	25.5	7.43	8	4¼	½	9/16	6¼	⅞	2¼	68.1	17.0	3.03	4.7	2.2	0.80	26	51	64	15000	11930	¾	45	65	110
9″	21.8	6.32	9	4 5/16	½	5/16	7	1	2½	84.9	18.9	3.67	5.2	2.4	0.90	28	31	35	13626	6530	¾	45	65	110
	25.0	7.28	9	4 7/16	½	⅜	7	1	2½	91.4	20.3	3.54	5.6	2.5	0.88	30	43	54	15000	8930	¾	45	65	115
	30.0	8.76	9	4⅝	½	9/16	7	1	2½	101.4	22.5	3.40	6.4	2.8	0.85	34	61	76	15000	11930	¾	50	70	120
	35.0	10.22	9	4¾	½	¾	7	1	2½	111.3	24.7	3.30	7.3	3.0	0.84	37	78	98	15000	11930	¾	50	70	125
10″ *	22.0	6.42	10	5	⅜	¼	7¼	1⅜	3	110.3	22.1	4.15	6.9	2.8	1.03	33	30	29	11740	5630	¾	55	75	135
	25.4	7.38	10	4 11/16	½	5/16	8	1	2¾	122.1	24.4	4.07	6.9	3.0	0.97	37	37	41	13364	6980	¾	55	75	135
	30.0	8.75	10	4 13/16	½	7/16	8	1	2¾	133.5	26.7	3.91	7.6	3.2	0.93	40	54	67	15000	10060	¾	60	80	140
	35.0	10.22	10	4 15/16	½	⅝	8	1	2¾	145.8	29.2	3.78	8.5	3.4	0.91	44	71	89	15000	11930	¾	65	85	145
	40.0	11.69	10	5 1/16	½	¾	8	1	2¾	158.0	31.6	3.68	9.4	3.7	0.90	47	89	111	15000	11930	¾	70	90	150
12″ *	25.0	7.35	12	5	⅜	¼	9¼	1⅜	3	175.5	29.2	4.89	7.3	2.9	1.00	44	39	35	10855	6080	¾	55	80	155
	31.8	9.26	12	5	9/16	⅜	9¾	1⅛	3	215.8	36.0	4.83	9.5	3.8	1.01	54	50	54	12933	7880	¾	60	85	160
	35.0	10.20	12	5 1/16	9/16	7/16	9¾	1⅛	3	227.0	37.8	4.72	10.0	3.9	0.99	57	62	73	14263	9630	¾	65	90	165
	40.8	11.84	12	5¼	¾	7/16	9¼	1⅜	3	268.9	44.8	4.77	13.8	5.3	1.03	67	66	81	14672	10350	¾	70	95	170
	45.0	13.10	12	5⅜	¾	9/16	9¼	1⅜	3	284.1	47.3	4.66	14.8	5.5	1.06	71	81	102	15000	11930	¾	75	100	175
	50.0	14.57	12	5½	¾	11/16	9¼	1⅜	3½	301.6	50.3	4.55	16.0	5.8	1.05	75	99	124	15000	11930	¾	80	105	180
	55.0	16.04	12	5⅝	¾	13/16	9¼	1⅜	3½	319.3	53.2	4.46	17.3	6.2	1.04	80	117	146	15000	11930	¾	85	110	185
15″ *	35.0	10.22	15	5½	7/16	5/16	11¾	1⅝	3½	367.9	49.0	6.00	11.6	4.2	1.06	74	59	53	10660	7430	¾	75	105	195
	42.9	12.49	15	5½	⅝	7/16	12½	1¼	3½	441.8	58.9	5.95	14.6	5.3	1.08	88	74	77	12446	9230	¾	80	110	200
	45.0	13.12	15	5 9/16	⅝	½	12½	1¼	3½	453.6	60.5	5.88	15.0	5.4	1.07	91	81	89	13166	10170	¾	85	115	205
	50.0	14.59	15	5⅝	⅝	9/16	12½	1¼	3½	481.1	64.2	5.74	16.0	5.7	1.05	96	99	119	14423	11930	¾	90	120	210
	55.0	16.06	15	5¾	⅝	⅝	12½	1¼	3½	508.7	67.8	5.63	17.0	5.9	1.03	102	117	146	15000	11930	¾	95	125	215
	60.8	17.68	15	6	⅞	9/16	11¾	1⅝	3½	609.0	81.2	5.87	26.0	8.7	1.21	122	106	131	14810	11930	¾	100	130	220
	65.0	18.91	15	6 1/16	⅞	11/16	11¾	1⅝	3½	632.1	84.3	5.78	27.2	8.9	1.20	126	121	151	15000	11930	¾	105	135	225
	70.0	20.38	15	6 3/16	⅞	¾	11¾	1⅝	3½	659.6	87.9	5.69	28.8	9.3	1.19	132	139	173	15000	11930	¾	110	140	230
	75.0	21.85	15	6¼	⅞	⅞	11¾	1⅝	3½	687.2	91.6	5.61	30.6	9.8	1.18	137	156	195	15000	11930	¾	115	145	235
	81.3	23.57	15	6⅜	1	13/16	11	2	3½	789.1	105.2	5.79	41.3	12.9	1.32	158	144	180	15000	11930	⅞	120	150	240
	85.0	24.65	15	6½	1	⅞	11	2	4	809.4	107.9	5.73	42.9	13.3	1.32	162	157	196	15000	11930	⅞	125	155	245
	90.0	26.12	15	6 9/16	1	1	11	2	4	837.0	111.6	5.66	45.2	13.8	1.32	167	175	218	15000	11930	⅞	130	160	250
	95.0	27.59	15	6 11/16	1	1 1/16	11	2	4	864.5	115.3	5.60	47.7	14.3	1.31	173	192	240	15000	11930	⅞	135	165	255
	100.0	29.08	15	6¾	1	1 3/16	11	2	4	892.4	119.0	5.54	50.2	14.8	1.31	179	210	263	15000	11930	⅞	140	700	260
18″ *	46.0	13.34	18	6	9/16	⅜	14¼	1⅞	3½	675.7	75.1	7.12	17.1	5.7	1.13	113	82	70	10300	8550	¾	90	115	255
	54.7	15.94	18	6	¾	7/16	15¼	1⅜	3½	795.5	88.4	7.07	21.2	7.1	1.15	133	99	99	11917	10350	⅞	100	125	265
	60.0	17.50	18	6⅛	¾	9/16	15¼	1⅜	3½	837.8	93.1	6.92	22.3	7.3	1.13	140	118	130	13226	11930	⅞	105	130	270
	65.0	18.98	18	6 3/16	¾	⅝	15¼	1⅜	3½	877.7	97.5	6.80	23.4	7.6	1.11	146	136	160	14140	11930	⅞	110	135	275
	70.0	20.46	18	6¼	¾	11/16	15¼	1⅜	3½	917.5	101.9	6.70	24.5	7.8	1.09	153	154	190	14832	11930	⅞	115	140	280
	75.6	22.04	18	7	1	9/16	14½	1¾	4	1141.8	126.9	7.20	46.3	13.2	1.45	190	121	135	13389	11930	⅞	120	145	305
	80.0	23.34	18	7 1/16	1	⅝	14½	1¾	4	1176.8	130.8	7.10	47.9	13.6	1.43	196	137	161	14169	11930	⅞	125	150	310
	85.0	24.81	18	7⅛	1	11/16	14½	1¾	4	1216.6	135.2	7.00	49.8	14.0	1.42	203	154	189	14854	11930	⅞	130	155	315
	90.0	26.29	18	7¼	1	13/16	14½	1¾	4	1256.5	139.6	6.91	51.9	14.3	1.40	209	172	215	15000	11930	⅞	135	160	320
20″	65.4	19.08	20	6¼	¾	½	17	1½	4	1169.5	116.9	7.83	27.9	8.9	1.21	175	120	117	11739	11250	⅞	110	145	295
	70.0	20.42	20	6 5/16	¾	9/16	17	1½	4	1214.2	121.4	7.71	28.9	9.2	1.19	182	136	144	12723	11930	⅞	115	150	300
	75.0	21.90	20	6⅜	¾	⅝	17	1½	4	1263.5	126.3	7.60	30.1	9.4	1.17	189	154	174	13589	11930	⅞	120	155	305
	81.4	23.74	20	7	1	⅝	16½	1¾	4	1466.3	146.6	7.86	45.8	13.1	1.39	220	144	158	13135	11930	⅞	125	160	330
	85.0	24.80	20	7 1/16	1	⅝	16½	1¾	4	1501.7	150.2	7.78	47.0	13.3	1.38	225	157	179	13713	11930	⅞	130	165	335
	90.0	26.26	20	7⅛	1	¾	16½	1¾	4	1550.3	155.0	7.68	48.7	13.7	1.36	233	174	208	14366	11930	⅞	135	170	340
	95.0	27.74	20	7 3/16	1	13/16	16½	1¾	4	1599.7	160.0	7.59	50.5	14.0	1.35	240	192	238	14896	11930	⅞	140	175	345
	100.0	29.20	20	7¼	1	⅞	16½	1¾	4	1648.3	164.8	7.51	52.4	14.4	1.34	247	210	262	15000	11930	⅞	145	180	350
21″ *	58.0	16.90	21	6½	9/16	7/16	16¾	2⅛	4	1143.0	108.8	8.22	24.5	7.5	1.20	163	108	90	10030	9680	⅞	105	145	250
*	75.0	22.05	21	7	13/16	½	15¾	2⅝	4	1524.0	145.1	8.32	41.9	12.0	1.38	218	131	127	11660	11700	⅞	120	160	270
24″ *	71.0	20.88	24	7	11/16	½	19¼	2⅜	4	1815.0	151.2	9.32	34.0	9.7	1.26	227	138	113	9820	10800	⅞	120	155	370
	79.9	23.33	24	7	⅞	½	20¾	1⅝	4	2087.2	173.9	9.46	42.9	12.2	1.36	261	144	122	10181	11250	⅞	130	165	380
	85.0	24.84	24	7 1/16	⅞	9/16	20¾	1⅝	4	2159.8	180.0	9.33	44.2	12.5	1.33	270	162	151	11209	11930	⅞	135	170	385
	90.0	26.30	24	7⅛	⅞	⅝	20¾	1⅝	4	2230.1	185.8	9.21	45.5	12.8	1.32	279	180	180	12055	11930	⅞	140	175	390
	95.0	27.79	24	7 3/16	⅞	11/16	20¾	1⅝	4	2301.5	191.8	9.08	47.0	13.0	1.30	288	198	210	12784	11930	⅞	145	180	395
	100.0	29.25	24	7¼	⅞	¾	20¾	1⅝	4	2371.8	197.6	9.05	48.4	13.4	1.29	296	215	240	13393	11930	⅞	150	185	400
	105.9	30.98	24	7⅞	1⅛	⅝	20¼	1⅞	5	2811.5	234.3	9.53	78.9	20.0	1.60	351	180	181	12068	11930	⅞	155	190	430
	110.0	32.18	24	7 15/16	1⅛	11/16	20¼	1⅞	5	2869.1	239.1	9.44	80.6	20.3	1.58	359	194	205	12664	11930	⅞	160	195	435
	115.0	33.67	24	8	1⅛	¾	20¼	1⅞	5	2940.5	245.0	9.35	82.8	20.7	1.57	368	212	235	13300	11930	⅞	165	200	440
	120.0	35.13	24	8 1/16	1⅛	13/16	20¼	1⅞	5	3010.8	250.9	9.26	84.9	21.1	1.56	376	230	265	13829	11930	⅞	170	205	445

AMERICAN STANDARD CHANNELS



I = Moment of Inertia.
S = Section Modulus.
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A. I. S. C. SPECIFICATIONS

(OBSOLETE—For Reference Only)

V = Max. Web Shear, kips.
F = Total Web Buckling, kips.
Fb = Unit Web Buckling.
R = Value ¾" Web Rivet.

SIZE	WT. PER FOOT	AREA SQ.IN	Dimensions							Axis 1-1			Axis 2-2				M	V	F	Fb	R
			d	b	p	t	f	o	g	I	S	r	I	S	r	y					
3"	4.1	1.19	3	1 7/16	¼	3/16	1¾	⅝	⅞	1.6	1.1	1.17	0.20	0.21	0.41	0.44	1.7	6.1	7.6	15000	3830
	5.0	1.46	3	1½	¼	¼	1¾	⅝	⅞	1.8	1.2	1.12	0.25	0.24	0.41	0.44	1.8	9.3	12	15000	5810
	6.0	1.75	3	1⅝	¼	⅜	1¾	⅝	⅞	2.1	1.4	1.08	0.31	0.27	0.42	0.46	2.1	13	16	15000	7990
4"	5.4	1.56	4	1 9/16	5/16	3/16	2¾	⅝	1	3.8	1.9	1.56	0.32	0.29	0.45	0.46	2.9	8.6	11	15000	4050
	6.25	1.82	4	1⅝	5/16	¼	2¾	⅝	1	4.1	2.1	1.50	0.38	0.32	0.45	0.46	3.2	12	15	15000	5560
	7.25	2.12	4	1¾	5/16	5/16	2¾	⅝	1	4.5	2.3	1.47	0.44	0.35	0.46	0.46	3.5	15	19	15000	7200
5"	6.7	1.95	5	1¾	5/16	3/16	3¾	⅝	1⅛	7.4	3.0	1.95	0.48	0.38	0.50	0.49	4.5	11	14	14625	4280
	9.0	2.63	5	1⅞	5/16	5/16	3¾	⅝	1⅛	8.8	3.5	1.83	0.64	0.45	0.49	0.48	5.3	20	24	15000	7315
	11.5	3.36	5	2 1/16	5/16	½	3¾	⅝	1⅛	10.4	4.1	1.76	0.82	0.54	0.49	0.51	6.2	28	35	15000	10625
6"	8.2	2.39	6	1 15/16	5/16	3/16	4½	¾	1⅛	13.0	4.3	2.34	0.70	0.50	0.54	0.52	6.5	14	17	13846	4500
	10.5	3.07	6	2 1/16	⅜	5/16	4½	¾	1⅛	15.1	5.0	2.22	0.87	0.57	0.53	0.50	7.5	23	28	15000	7070
	13.0	3.81	6	2 3/16	⅜	7/16	4½	¾	1⅜	17.3	5.8	2.13	1.1	0.65	0.53	0.52	8.7	31	39	15000	9840
	15.5	4.54	6	2¼	⅜	9/16	4½	¾	1⅜	19.5	6.5	2.07	1.3	0.73	0.53	0.55	9.8	40	50	15000	11930
7"	9.8	2.85	7	2 1/16	⅜	3/16	5½	¾	1¼	21.1	6.0	2.72	0.98	0.63	0.59	0.55	9	18	19	13135	4730
	12.25	3.58	7	2 3/16	⅜	5/16	5½	¾	1¼	24.1	6.9	2.59	1.2	0.71	0.58	0.53	10	26	33	15000	7070
	14.75	4.32	7	2 5/16	7/16	7/16	5½	¾	1¼	27.1	7.7	2.51	1.4	0.79	0.57	0.53	12	35	44	15000	9430
	17.25	5.05	7	2⅜	7/16	½	5½	¾	1½	30.1	8.6	2.44	1.6	0.86	0.56	0.55	13	44	55	15000	11770
	19.75	5.79	7	2½	7/16	⅝	5½	¾	1½	33.1	9.4	2.39	1.8	0.96	0.56	0.58	14	53	66	15000	11930
8"	11.5	3.36	8	2¼	⅜	¼	6¼	⅞	1⅜	32.3	8.1	3.10	1.3	0.79	0.63	0.58	12	21	22	12493	4950
	13.75	4.02	8	2 5/16	⅜	5/16	6¼	⅞	1⅜	35.8	9.0	2.99	1.5	0.86	0.62	0.56	14	29	35	14606	6820
	16.25	4.76	8	2 7/16	7/16	⅜	6¼	⅞	1½	39.8	9.9	2.89	1.8	0.94	0.61	0.56	15	38	47	15000	8890
	18.75	5.49	8	2½	7/16	½	6¼	⅞	1½	43.7	10.9	2.82	2.0	1.0	0.60	0.57	16	47	58	15000	10920
	21.25	6.23	8	2⅝	7/16	9/16	6¼	⅞	1½	47.6	11.9	2.77	2.2	1.1	0.60	0.59	18	56	69	15000	11930
9"	13.4	3.89	9	2 7/16	7/16	¼	7¼	⅞	1⅜	47.3	10.5	3.49	1.8	0.97	0.67	0.61	16	25	25	11917	5180
	15.0	4.39	9	2½	7/16	5/16	7¼	⅞	1⅜	50.7	11.3	3.40	1.9	1.0	0.67	0.59	17	31	35	13509	6385
	20.0	5.86	9	2⅝	½	7/16	7¼	⅞	1½	60.6	13.5	3.22	2.4	1.2	0.65	0.59	20	48	60	15000	10035
	25.0	7.33	9	2 13/16	½	⅝	7¼	⅞	1½	70.5	15.7	3.10	3.0	1.4	0.64	0.61	24	66	82	15000	11930
10"	15.3	4.47	10	2⅝	7/16	¼	8¼	⅞	1½	66.9	13.4	3.87	2.3	1.2	0.72	0.64	20	29	27	11401	5400
	20.0	5.86	10	2¾	7/16	⅜	8¼	⅞	1½	78.5	15.7	3.66	2.8	1.3	0.70	0.61	24	45	55	14609	8540
	25.0	7.33	10	2⅞	½	½	8¼	⅞	1¾	90.7	18.1	3.52	3.4	1.5	0.68	0.62	27	63	79	15000	11800
	30.0	8.80	10	3 1/16	½	11/16	8¼	⅞	1¾	103.0	20.6	3.42	4.0	1.7	0.67	0.65	31	81	101	15000	11930
	35.0	10.27	10	3 3/16	½	13/16	8¼	⅞	1¾	115.2	23.0	3.34	4.6	1.9	0.67	0.69	35	98	123	15000	11930
12"	20.7	6.03	12	2 15/16	½	¼	10	1	1¾	128.1	21.4	4.61	3.9	1.7	0.81	0.70	32	40	37	11165	6300
	25.0	7.32	12	3 1/16	½	⅜	10	1	1¾	143.5	23.9	4.43	4.5	1.9	0.79	0.68	36	56	63	13631	8710
	30.0	8.79	12	3 3/16	½	½	10	1	1¾	161.2	26.9	4.28	5.2	2.1	0.77	0.68	40	73	92	15000	11480
	35.0	10.26	12	3 5/16	⅝	⅝	10	1	2	178.8	29.8	4.18	5.9	2.3	0.76	0.69	45	91	114	15000	11930
	40.0	11.73	12	3 7/16	⅝	¾	10	1	2	196.5	32.8	4.09	6.6	2.5	0.75	0.72	49	109	136	15000	11930
15"	33.9	9.90	15	3⅜	⅝	⅜	12¼	1⅜	2	312.6	41.7	5.62	8.2	3.2	0.91	0.79	63	72	74	12255	9000
	35.0	10.23	15	3 7/16	⅝	7/16	12¼	1⅜	2	318.7	42.5	5.58	8.4	3.2	0.91	0.79	64	76	80	12666	9495
	40.0	11.70	15	3½	⅝	½	12¼	1⅜	2	346.3	46.2	5.44	9.3	3.4	0.89	0.78	69	94	110	14091	11700
	45.0	13.17	15	3⅝	⅝	⅝	12¼	1⅜	2	373.9	49.8	5.33	10.3	3.6	0.88	0.79	75	111	139	15000	11930
	50.0	14.64	15	3 11/16	11/16	11/16	12¼	1⅜	2¼	401.4	53.6	5.24	11.2	3.8	0.87	0.80	80	129	161	15000	11930
	55.0	16.11	15	3 13/16	11/16	13/16	12¼	1⅜	2¼	429.0	57.2	5.16	12.1	4.1	0.87	0.82	86	147	183	15000	11930

PART III

A. I. S. C. SPECIFICATIONS

AMERICAN INSTITUTE OF STEEL CONSTRUCTION

SPECIFICATION FOR THE DESIGN, FABRICATION AND ERECTION OF STRUCTURAL STEEL FOR BUILDINGS

(Riveted, Bolted and Arc-Welded Construction)

This Specification defines the practice adopted by the American Institute of Steel Construction in the design, fabrication, and erection of structural steel for buildings.

ADMINISTRATIVE PROVISIONS

Section 1. TYPES OF CONSTRUCTION.

Three basic types of design and design assumption are permissible, under the respective conditions stated hereinafter, and each will govern in a specific manner the sizes of members and the types and strength of their connections.

Type 1, commonly designated as "rigid-frame" (continuous, restrained frame), assumes that the end connections of all members in the frame have sufficient rigidity to hold virtually unchanged the original angles between such members and the members to which they connect.

Type 2, commonly designated as "conventional" or "simple" framing (unrestrained, free-ended), assumes that the ends of beams and girders are connected for shear only, and are free to rotate under load.

Type 3, commonly designated as "semi-rigid framing" (partially restrained), assumes that the connections of beams and girders possess a dependable and known moment capacity intermediate in degree between the complete rigidity of Type 1 and the complete flexibility of Type 2.

All connections shall be consistent in their design with the assumptions as to type of construction, as called for on the design drawings.

Type 1 construction is unconditionally permitted under this Specification. It is a necessary condition of this type that the calculated stresses and resulting strains in all members and their connections occur within the elastic range, and that the stresses do not exceed those allowed in Section 15 of this Specification.

Type 2 construction is permitted under this Specification, subject to the stipulations of the following paragraph wherever applicable. Beam-to-column connections with seats for the reactions and with top clip angles for lateral support only, are classed under Type 2.

In tier buildings, designed in general as Type 2 construction, in that the beam-to-column connections other than wind connections are flexible, the distribution of the wind moments, as between the several joints of the frame, may be made by a recognized empirical method provided that either:

1. The wind connections, designed to resist the assumed wind moments, are adequate to resist the moments induced by the gravity loading and the wind loading, at the increased unit stresses permitted therefor, or,
2. The wind connections, if welded and if designed to resist the assumed wind moments, are so designed that larger moments, induced by the gravity loading under the actual condition of restraint, will be relieved by deformation of the connection material without over-stress in the welds.

Type 3 (semi-rigid) construction will be permitted only upon evidence that the connections to be used are capable of resisting definite moments without overstress of the welds.* The proportioning of main members joined by such connections shall be predicated upon no greater degree of end restraint than the minimum known to be effected by the respective connections.*

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* The American Institute of Steel Construction expects to publish designs of beam-to-column connections with a statement of the experimentally determined bending resistance thereof.

Types 2 and 3 construction may necessitate some non-elastic but self-limiting deformation of a structural steel part, but under forces which do not overstress the rivets, bolts or welds.

Section 2. DEFINITIONS AND NOMENCLATURE, WELDED CONSTRUCTION.

All terms herein relating to welds, welding and gas cutting shall be construed in accordance with the standard "Definitions of Welding Terms and Master Chart of Welding Processes" of the American Welding Society, as amended to date.

Section 3. PLANS AND DRAWINGS. STRESS SHEETS.

(a) Plans.

The plans (design drawings) shall show a complete design with sizes, sections, and the relative locations of the various members. Floor levels, column centers, and offsets shall be dimensioned. Plans shall be drawn to a scale large enough to convey the information adequately.

Plans shall indicate the type or types of construction (as defined in Section 1) to be employed; and shall be supplemented by such data as to the assumed loads, and the shears, moments and axial forces to be resisted by all members and their connections, as may be required for the proper preparation of the shop drawings.

(b) Shop Drawings.

Shop drawings, giving complete information necessary for the fabrication of the component parts of the structure, including the location, type, size and extent of all welds, shall be prepared in advance of the actual fabrication. They shall clearly distinguish between shop and field rivets, bolts and welds.

Shop drawings shall be made in conformity with the best modern practice and with due regard to speed and economy in fabrication and erection.

(c) Notations for Welding.

Note shall be made on the plans and on the shop drawings of those joints or groups of joints in which it is especially important that the welding sequencé and technique of welding be carefully controlled to minimize locked-up stresses and distortion.

Weld lengths called for on the plans and on the shop drawings shall be the net effective lengths.

(d) Symbols for Welding.

Welding symbols used on plans and shop drawings shall preferably be the American Welding Society symbols; other adequate welding symbols may be used, provided a complete explanation thereof is shown on the plans or drawings.

Section 4. LOADS AND FORCES.

(a) Dead Load.

The dead load to be assumed in design shall consist of the weight of the steelwork and all material fastened thereto or supported thereby.

(b) Live Load.

The live load, and snow load if any, shall be that stipulated by the Code under which the structure is being designed or that required by the conditions involved. In general, the live loads should not be less than those recommended in the "American Standard Building Requirements for Minimum Design Loads in Buildings and Other Structures, A58.1," latest edition.

(c) Wind.

Proper provision shall be made for stresses caused by wind both during erection and after completion of the building. The wind pressure is dependent upon the conditions of exposure and geographical location of the structure. The allowable stresses specified in Paragraphs (d) and (e) of Section 15, are based upon the steel frame being designed to carry a wind pressure of not less than twenty (20) pounds per square foot on the vertical projection of the finished structure.

(d) Other Forces.

Structures in localities subject to earthquakes, hurricanes, and other extraordinary conditions shall be designed with due regard for such conditions.

Section 5. WELDING.

(a) Welding.

Welds shall be made only by operators who have been previously qualified by tests, as prescribed in the "Standard Qualification Procedure" of the American Welding Society, to perform the type of work required, except that this provision need not apply to tack welds not later incorporated into finished welds carrying calculated stress.

(b) Rivets and Bolts in Combination with Welds.

In new work, rivets or bolts in combination with welds shall not be considered as sharing the stress, and welds shall be provided to carry the entire stress for which the connection is designed.

In making welded alterations to structures, existing rivets may be utilized for carrying stresses resulting from existing dead loads, and the welding need be adequate only to carry all additional stress.

Section 6. TURNED BOLTS.

Turned bolts in close fitting holes as specified in Section 33(e), may be used in shop or field work where it is impracticable to drive satisfactory rivets. The finished shank shall be long enough to provide full bearing, and washers shall be used under the nuts to give full grip when the nuts are turned tight.

The term "turned bolts," as used in this Specification, embraces all bolts regardless of the manufacturing process, which have a tolerance on the nominal diameter of 0 over, .006″ under, and which have "regular semi-finished" heads conforming to "American Standard B18.2—1941" of the American Institute of Bolt, Nut and Rivet Manufacturers.

Section 7. ERECTION.

(a) Bracing.

The frame of steel skeleton buildings shall be carried up true and plumb, and temporary bracing shall be introduced wherever necessary to take care of all loads to which the structure may be subjected, including equipment, and the operation of same. Such bracing shall be left in place as long as may be required for safety.

(b) Adequacy of Temporary Connections.

As erection progresses, the work shall be securely bolted up, or welded, to take care of all dead load, wind and erection stresses.

(c) Erection Stresses.

Wherever piles of material, erection equipment or other loads are carried during erection, proper provision shall be made to take care of stresses resulting from the same.

(d) Alignment.

No riveting or welding shall be done until as much of the structure as will be stiffened thereby has been properly aligned.

(e) Field Connections.

All field connections may be made with unfinished bolts, except as follows:

Rivets or welds shall be used for the following connections; except that turned bolts may be used in lieu of rivets as specified in Section 6:

Column splices in all tier structures 200 feet or more in height.

Column splices in tier structures 100 to 200 feet in height, if the least horizontal dimension is less than 40 percent of the height.

Column splices in tier structures less than 100 feet in height, if the least horizontal dimension is less than 25 percent of the height.

Connections of all beams and girders to columns and of any other beams and girders on which the bracing of columns is dependent, in structures over 125 feet in height.

Roof-truss splices and connections of trusses to columns, column splices, column bracing, knee braces and crane supports, in all structures carrying cranes of over 5-ton capacity.

Connections for supports of running machinery, or of other live loads which produce impact or reversal.

Any other connections stipulated on the design plans.

For the purpose of this Section, the height of a tier structure shall be taken as the vertical distance from the curb level to the highest point of the roof beams, in the case of flat roofs, or to the mean height of the gable, in the case of roofs having a rise of more than 2-2/3 in 12. Where the curb level has not been established, or where the structure does not adjoin a street, the mean level of the adjoining land shall be used instead of curb level. Penthouses may be excluded in computing the height of structure.

(f) Field Riveting.

Rivets driven in the field shall be heated and driven with the same care as those driven in the shop.

(g) Field Welding.

All field assembly and welding shall be executed in accordance with the requirements for shop fabrication, excepting such as manifestly apply to shop conditions only.

Any shop paint on surfaces adjacent to joints to be field welded shall be thoroughly removed to expose clean steel for a distance of at least 2 inches on either side of the joint.

(h) Field Painting.

All field rivets, field bolts and field welds, also all serious abrasions to the shop coat, shall be spot painted with the material used for the shop coat, or an equivalent, and all mud and other firmly attached and objectionable foreign materials shall be removed, before general field painting.

Responsibility for this touch-up and cleaning, as well as for general painting, shall be allocated in accordance with accepted local practices and this allocation shall be set forth explicitly in the contract.

Section 8. INSPECTION.

(a) General.

Material and workmanship at all times shall be subject to the inspection of experienced engineers representing the purchaser.

(b) Cooperation.

All inspection as far as possible shall be made at the place of manufacture, and the Contractor or Manufacturer shall cooperate with the Inspector, permitting access for inspection to all places where work is being done.

(c) Rejections.

Material or workmanship not conforming to the provisions of this Specification may be rejected at any time defects are found during the progress of the work.

(d) Inspection of Welding.

The inspection of welding shall be performed in accordance with the provisions of Section 5 of the "Code for Arc and Gas Welding in Building Construction" of the American Welding Society, as amended to date.

TECHNICAL PROVISIONS

PART I. MATERIAL

Section 9. MATERIAL.

(a) Structural Steel.

Structural steel shall conform to the "Standard Specifications for Structural Steel for Bridges and Buildings, Serial Designation A 7" of the American Society for Testing Materials, as amended to date.

(b) Rivet Steel.

Rivet steel shall conform to the "Standard Specifications for Structural Rivet Steel, Serial Designation A141," of the American Society for Testing Materials, as amended to date.

(c) Other Metals.

Cast steel, cast iron and other metals shall conform to the applicable Specifications of the American Society for Testing Materials, as amended to date. Cast steel for welding shall be of a grade designated as weldable in said Specifications.

(d) Stock Material.

Stock material shall be of a quality equal to that called for by Paragraph (a). Mill test reports shall constitute sufficient record as to the material taken from stock.

Unidentified stock material, if free from surface imperfections, may be used for short sections of minor importance, or for small unimportant details, where the precise physical properties of the material would not affect the strength of the structure.

(e) Filler Metal.

Arc-Welding electrodes shall conform to the requirements of the "Specifications for Iron and Steel Arc-Welding Electrodes" of the American Welding Society, latest edition. Electrodes shall be of Classification Numbers E6010, E6011, E6012, E6013, E6020 or E6030 and shall be suitable for the positions and other conditions of intended use.

With each container of electrodes the manufacturer shall furnish instructions giving recommended voltage and amperage (and polarity if direct current) for all uses and welding positions for which the electrode is suitable.

PART II. LOADS AND STRESSES

Section 10. LOADS AND FORCES.

(a) Steel structures shall be designed to sustain the following loads and forces:

1. Dead Load.
2. Live Load.
3. Impact.
4. Wind and other Lateral and Longitudinal Forces.
5. Erection Loads.
6. Other Forces.

(b) Dead Load, Live Load and Other Forces.

The dead load, live load, snow load if any, wind force and any other forces due to extraordinary conditions, to be assumed in design, shall be as specified in Section 4, unless otherwise specified in the applicable Building Code or General Specification.

(c) Impact.

For structures carrying live loads which induce impact or vibration, the assumed live load shall be increased sufficiently to provide for same.

If not otherwise specified, the increase shall be:

For supports of elevators	100 percent
For traveling crane support girders and their connections	25 "
For supports of light machinery, shaft or motor driven, not less than	20 "
For supports of reciprocating machinery or power driven units, not less than	50 "
For threaded hanger rods supporting floors and balconies	33⅓ "

(d) Crane Runway Horizontal Forces.

The lateral force on crane runways to provide for the effect of moving crane trolleys shall, if not otherwise specified, be 20 percent of the sum of the weights of the lifted load and of the crane trolley (but exclusive of other parts of the crane), applied at the top of rail one-half on each side of runway; and shall be considered as acting in either direction normal to the runway rail.

The longitudinal force shall, if not otherwise specified, be taken as 10 percent of the maximum wheel loads of the crane applied at the top of rail.

Section 11. MEMBERS SUBJECT TO REVERSAL OF STRESS.

(a) Section of Member.

The sectional area of the portion between connections, of members subject to reversal of stress, need not be increased by reason of the reversal, but shall be sufficient in area and disposition to provide for the maximum compression, and the maximum tension, separately.

(b) Reinforcement at Connections.

The sectional area of members subject to loads (other than wind loads) producing alternating tensile and compressive stresses shall be augmented, at the approach to a connection, by riveting or welding on additional material, so that the augmented section shall comply with the following rule:

To the net total compressive stress, and to the net total tensile stress, add arithmetically 50 percent of the smaller of these two; and proportion the connected material, and the connecting rivets, bolts, pins or welds, for each of the two increased stresses thus separately obtained at the unit stresses prescribed in Section 15 (a).

If the reversal may be expected to occur over 100,000 times in the life of the building, the unit stresses in the connected material and in the connecting rivets, bolts, pins or welds shall not exceed 75 percent of those specified in Section 15 (a). Sharp notches copes and other sudden changes of cross section shall be particularly avoided in and adjacent to such connections.

Section 12. COMBINED STRESSES.

(a) Axial and Bending.

Members subject to both axial and bending stresses shall be so proportioned that the quantity

$\frac{f_a}{F_a} + \frac{f_b}{F_b}$ shall not exceed unity, in which

F_a = axial unit stress that would be permitted by this Specification if axial stress only existed.

F_b = bending unit stress that would be permitted by this Specification if bending stress only existed.

f_a = axial unit stress (actual) = axial stress divided by area of member.

f_b = bending unit stress (actual) = bending moment divided by section modulus of member.

(b) Shear with Tension or Compression.

Rivets, bolts and welds subject to shearing and externally applied tensile or compressive forces shall be so proportioned that the combined unit stress will not exceed the unit stress allowed for shear in Section 15 (a).

Section 13. COMPOSITE BEAMS.

(a) Definition.

The term "composite beam" shall apply to any rolled or fabricated steel floor beam entirely encased in a poured concrete haunch at least four inches wider, at its narrowest point than the flange of the beam, supporting a concrete slab on each side without openings adjacent to the beam; provided that the top of the beam is at least 1½ inches below the top of the slab and at least 2 inches above the bottom of the slab; provided that a good grade of stone or gravel concrete, with Portland cement, is used; and provided that the concrete haunch has adequate mesh, or other reinforcing steel, throughout its whole depth and across its soffit.

(b) Design Assumptions.

Composite beams may be figured on the assumption that:

1. The steel beam carries unassisted all dead loads prior to the hardening of the concrete, with due regard for any temporary support provided, and
2. The steel and concrete carry by joint action all loads, dead and live, applied after the hardening of the concrete.

(c) Unit Stresses.

The total tensile unit stress in the extreme fibre of the steel beam thus computed shall not exceed 20,000 pounds per square inch. (Section 15 (a)).

The maximum stresses in the concrete, and the ratio of Young's moduli, for steel and concrete, shall be as prescribed by the specifications governing the design of reinforced concrete for the structure.

(d) End Shear.

The web and the end connections of the steel beam shall be designed to carry the total dead and live load, except as this may be reduced by the provision of other proper support.

Section 14. EFFECTIVE SPAN LENGTH.

(a) Simple Spans.

Beams, girders and trusses shall ordinarily be designed on the basis of simple spans whose effective length is equal to the distance between centers of gravity of the members to which they deliver their end reactions.

(b) End Restraint.

When designed on the assumption of end restraint full or partial, due to continuous, semi-continuous or cantilever action, the beams, girders and trusses, as well as the sections of the members to which they connect, shall be designed to carry the shears and moments so introduced, as well as all other forces, without exceeding at any point the unit stresses prescribed in Section 15 (a); except that some non-elastic but self-limiting deformation of a part of the connection may be permitted when this is essential to the avoidance of overstressing of a weld.

PART III. UNIT STRESSES

Section 15. ALLOWABLE UNIT STRESSES.

Except as provided in this Section under "Bending," under "Wind Only" and under "Wind and Other Forces" and as provided in Section 1, final paragraph, all parts of the structure shall be so proportioned that the unit stress in pounds per square inch shall not exceed the following values:

(a) Structural Steel, Rivets, Bolts and Weld Metal.

(1) TENSION.

Structural Steel, net section	20,000
Butt welds, section through throat	20,000
Rivets, on area based on nominal diameter	20,000
Bolts and other threaded parts. on nominal area at root of thread	20,000

(2) COMPRESSION.

Columns, gross section

For axially loaded columns with values of l/r not greater than 120	$17{,}000 - 0.485 \frac{l^2}{r^2}$
For axially loaded columns (bracing and other secondary members) with values of l/r greater than 120 (for main members, see Section 16 (b)).	$\dfrac{18{,}000}{1 + \dfrac{l^2}{18{,}000\,r^2}}$

in which l is the unbraced length of the column, and r is the corresponding radius of gyration of the section, both in inches.

Plate Girder Stiffeners, gross section	20,000
Webs of Rolled Sections at toe of fillet (Crippling, see Section 26 (h))	24,000
Butt Welds—Section through throat (crushing)	20,000

(3) BENDING.

Tension on extreme fibers of rolled sections, plate girders, and built-up members. (See Section 26 (a))	20,000

Compression on extreme fibers of rolled sections plate girders, and built-up members.

With $\frac{ld}{bt}$ not in excess of 600	20,000
With $\frac{ld}{bt}$ in excess of 600	$\dfrac{12{,}000{,}000}{\frac{ld}{bt}}$

in which l is the unsupported length and d the depth, of the member; b is the width, and t the thickness, of its compression flange; all in inches; except that l shall be taken as twice the length of the compression flange of a cantilever beam not fully stayed at its outer end against translation or rotation.

Stress on extreme fibers of pins	30,000

Fiber stresses in butt welds, due to bending, shall not exceed the values prescribed for tension and compression, respectively.

Fully continuous beams and girders may be proportioned for negative moments which are maximum at interior points of support, at a unit bending stress 20 percent higher than above stated; provided that the section modulus used over supports shall not be less than that required for the maximum positive moments in the same beam or girder, and provided that the compression flange shall be regarded as unsupported from the support to the point of contraflexure.

For columns proportioned for combined axial and bending stresses, the maximum unit bending stress Fb, Sect. 12 (a) may be taken at 24,000 pounds per square inch, when this stress is induced by the gravity loading of fully or partially restrained beams framing into the columns.

(4) SHEARING.

Rivets	15,000
Pins, and turned bolts in reamed or drilled holes	15,000
Unfinished bolts	10,000
Webs of beams and plate girders, gross section	13,000

Weld Metal	
on section through throat of fillet weld, or on faying surface area of plug or slot weld	13,600
on section through throat of butt weld	13,000

(Stress in a fillet weld shall be considered as shear on the throat, for any direction of applied stress. Neither plug nor slot welds shall be assigned any values in resistance to stresses other than shear.)

(5) BEARING.	Double Shear	Single Shear
Rivets	40,000	32,000
Turned bolts in reamed or drilled holes	40,000	32,000
Unfinished bolts	25,000	20,000
Pins	32,000	
Contact Area		
Milled Stiffeners and Other Milled Surfaces	30,000	
Fitted Stiffeners	27,000	
Expansion rollers and rockers (pounds per linear inch)	600d	

in which d is diameter of roller or rocker in inches.

(b) Cast Steel.

Compression and Bearing, same as for Structural Steel.
Other Unit Stresses, 75 percent of those for Structural Steel.

(c) Masonry Bearing.

Granite	800
Sandstone and Limestone	400
Portland Cement Concrete, unless otherwise specified	600
Hard Brick in Cement Mortar	250

(d) Wind Only.

Members subject only to stresses produced by wind forces may be proportioned for unit stresses 33⅓ percent greater than those specified for dead and live load stresses. A corresponding increase may be applied tothe allowable unit stresses in their connecting rivets, bolts or welds.

(e) Wind and Other Forces.

Members subject to stresses produced by a combination of wind and other loads may be proportioned for unit stresses 33⅓ percent greater than those specified for dead and live load stresses, provided the section thus required is not less than that required for the combination of dead load, live load, and impact (if any). A corresponding increase may be applied to the allowable unit stresses in their connecting rivets, bolts or welds.

(f) Effective Areas of Weld Metal.

The effective area of butt and fillet welds shall be considered as the effective length of weld times the effective throat thickness.

The effective shearing area of plug and slot welds shall be considered as the nominal cross-sectional area of the hole or slot, in the plane of the faying surface.

The effective area of fillet welds in holes and slots shall be computed as above specified for fillet welds, using for the effective length, the length of center line of the weld through the center of the plane through the throat. However, in the case of overlapping fillets, the effective area shall not exceed the nominal cross-sectional area of the hole or slot, in the plane of the faying surface.

The effective length of a fillet weld shall be the overall length of full-size fillet, including returns.

The effective length of a butt weld shall be the width of the part joined, when ends of the weld are made as specified in Section 33 (m), final paragraph. A transverse skewed butt weld shall not be assumed in computations to be longer than the width of the joint or piece perpendicular to the direction of stress.

The effective throat thickness of a fillet weld shall be the shortest distance from the root to the face of the diagrammatic weld. (The effective throat thickness of an equal leg 45° fillet weld is 0.707 times the nominal size of the weld.)

The effective throat thickness of a complete-penetration butt weld (i. e., a butt weld conforming to the requirements of Section 33 (m), 2nd paragraph) shall be the thickness of the thinner part joined.

The effective throat thickness of an incomplete-penetration butt weld (i. e., a butt weld not conforming to the requirements of Section 33 (m), 2nd paragraph, but conforming to same Section 3rd paragraph) shall, for design purposes, be considered as 75 percent of the thickness of the thinner part joined.

PART IV. DESIGN

Section 16. SLENDERNESS RATIO.

(a) The ratio of unbraced length to least radius of gyration $\frac{l}{r}$ for compression members and for tension members other than rods shall not exceed:

For main compression members	120
For bracing and other secondary members in compression	200
For main tension members	240
For bracing and other secondary members in tension	300

(b) The slenderness of a main compression member may exceed 120, but not 200, provided that it is not ordinarily subject to shock or vibratory loads and provided that its unit stress under full design loading shall not exceed the following fraction of that stipulated under Section 15 (a)(2) for its actual ratio l/r:

$$1.6 - \frac{l}{200\,r}$$

Section 17. DEPTH RATIO.

(a) Simple Spans.

The depth of beams and girders in floors shall if practicable be not less than 1/24 of the span, and where subject to shocks or vibrations not less than 1/20. If members of less depth are used, the unit stress in bending shall be decreased in the same ratio as the depth is decreased from that above recommended.

The depth of roof purlins shall if practicable be not less than 1/24 of the span, and in no case less than 1/30 of the span, except in the case of corrugated sheeting roofs, with a slope not less than 4¾ in 12.

Beams and girders supporting plastered ceilings shall if practicable be so proportioned that the maximum live load deflection will not exceed 1/360 of the span.

(b) Restrained and Continuous Spans.

Minimum depth-ratios for restrained and continuous spans shall if practicable be such that the deflections at critical points will be not greater than those of simple spans of the minimum depth-ratio recommended under Paragraph (a).

(c) Secondary Tension Members.

The horizontal projection of the length of bracing and secondary members in tension, other than rods, shall if practicable not exceed 90 times the depth.

Section 18. MINIMUM THICKNESS OF MATERIAL.

(a) Main Material.

The minimum thickness of steel except for linings, fillers, and the webs of rolled beams and channels, shall be:

For exterior construction, fully accessible for repainting, ¼ inch.

For exterior construction, not fully accessible for repainting, 5/16 inch, except as noted in the following clause.

For exterior lintels supporting masonry or wood and with steel partially exposed, on structures over two stories in height, 7/16 inch.

For interior construction, fully accessible for repainting, ¼ inch.

For exterior or interior construction, permanently sealed against moisture or change of air, 3/16 inch.

The foregoing thicknesses presume the absence of any atmospheric agents more corrosive than rain and fog; and shall be suitably increased if contact with such more corrosive agents is to be expected.

(b) Gusset Plates.

Gusset plates connecting truss members stressed to more than 35,000 pounds shall be not less than ⅜ inch thick.

(c) Projecting Elements Under Compression.

Projecting elements of members subjected to axial compression or compression due to bending shall have ratios of width to thickness not greater than the following:

Single angle struts 12.

Double-angle struts, angles or plates projecting from girders, columns or other compression members; compression flanges of beams; stiffeners on plate girders; flanges or stems of tees; 16.

The width of plates shall be taken from the free edge to the first row of rivets or welds; the width of legs of angles, channels and zees, and of the stems of tees, shall be taken as the full nominal dimension; the width of flanges of beams and tees shall be taken as one-half the full nominal width. The thickness of a sloping flange shall be measured halfway between a free edge and the corresponding face of the web.

When a projecting element exceeds the width-to-thickness ratio prescribed in the preceding paragraph, but would conform to same and would satisfy the stress requirements with a portion of its width considered as removed, the member will be considered acceptable without the actual removal of the excess width.

(d) Compression Members.

In compression members the unsupported width of web, cover or diaphragm plates between the nearest lines of rivets or welds, or between the roots of the flanges in case of rolled sections, shall not exceed 40 times the thickness.

When the unsupported width exceeds this limit, but a portion of its width no greater than 40 times the thickness would satisfy the stress requirements, the member will be considered acceptable.

The unsupported width of cover plates perforated with a succession of access holes, only the least net width across holes being assumed available to resist compression, may exceed 40, but shall not exceed 50, times the thickness.

Section 19. GROSS AND NET SECTIONS.

(a) Definitions.

The gross section of a member at any point shall be determined by summing the products of the thickness and the gross width of each element as measured normal to the axis of the member. The net section shall be determined by substituting for the gross width the net width computed in accordance with paragraphs (c) to (g) of this Section.

(b) Application.

Unless otherwise specified, tension members shall be designed on the basis of net section. Columns shall be designed on the basis of gross section. Beams and girders shall be designed in accordance with Section 26 (a).

In determining the net section across plug or slot welds the weld metal shall not be considered as adding to the net area.

(c) Net Width.

In the case of a chain of holes etxending across a part in any diagonal or zigzag line, the net width of the part shall be obtained by deducting from the gross width the sum of the diameters of all the holes in the chain, and adding, for each gage space in the chain, the quantity

$$\frac{s^2}{4g} \text{ where}$$

s = longitudinal spacing (pitch) in inches of any two successive holes.

g = transverse spacing (gage) in inches of the same two holes.

The critical net section of the part is obtained from that chain which gives the least net width.

(d) Angles.

For angles, the gross width shall be the sum of the widths of the legs less the thickness. The gage for holes in opposite legs shall be the sum of the gages from back of angle less the thickness.

(e) Splice Members.

For splice members, the thickness considered shall be only that part of the thickness of the member which has been developed by rivets or welds beyond the section considered.

(f) Size of Holes.

In computing net area the diameter of a rivet hole shall be taken as ⅛ inch greater than the nominal diameter of the rivet.

(g) Pin Holes.

In pin connected tension members, other than forged eyebars, the net section across the pin hole, transverse to the axis of the member, shall be not less than 135 percent, and the net section beyond the pin hole, parallel with the axis of the member, not less than 90 percent, of the net section of the body of the member.

In all pin-connected riveted members the net width across the pin hole, transverse to the axis of the member, shall not exceed 8 times the thickness of the member at the pin, unless lateral buckling is prevented.

Section 20. EXPANSION.

(a) Transverse Expansion.

No provision for transverse expansion in structures need be made in wall bearing spans of 50 feet and under. Wall bearing spans of over 50 feet and up to and including 100 feet shall slide on smooth surfaces at one end. Wall bearing spans of over 100 feet shall have expansion rollers or rockers at one end. Expansion ends shall be secured against lateral movement; fixed ends against movement in any direction.

(b) Longitudinal Expansion.

Provision shall be made for longitudinal expansion of the structure. All expansion provisions shall be figured for 100 degrees F. variation in temperature and for a coefficient of expansion of 0.0000065 per degree per unit of length. Expansion joints in buildings having masonry wall enclosures shall be so spaced as to inhibit visible cracking of the walls.

Section 21. CONNECTIONS.

(a) Minimum Connections.

Connections carrying calculated stresses, except for lacing, sag bars, and girts, shall be designed for not less than 10,000 pounds, if welded; or if riveted or bolted, shall have no fewer than two rivets or two bolts.

(b) Eccentric Connections.

Members meeting at a point shall have their gravity axes meet at a point if practicable; if not, provision shall be made for bending stresses due to the eccentricity.

(c) Placement of Rivets and Welds.

The rivets or welds at the ends of any member transmitting stresses into that member should preferably have their centers of gravity on the gravity axis of the member; otherwise, provision shall be made for the effect of the resulting eccentricity. Pins may be so placed as to counteract the effect of bending due to dead load.

(d) Unrestrained Members.

Except as otherwise indicated by the designer, all connections of beams, girders or trusses shall be designed as flexible, and may ordinarily be proportioned for the reaction shears only. If, however, the eccentricity of the connection is excessive, provision shall be made for the resulting moment.

Flexible beam connections shall permit the ends of the beam to rotate sufficiently to accommodate its deflection by providing for a horizontal displacement of the top flange as determined as follows:

$e = .007d$ if the beam is designed for full uniform load and for live load deflection not exceeding 1/360th of the span (see Section 17 (a));

or $e = \frac{fL}{3,625,000}$ if the beam is designed for full uniform load producing the unit stress f at mid span;

where e = the horizontal displacement between the top and bottom of the beam at its end, in inches.

f = the flexural unit stress in the beam at mid span; p.s.i.

d = The depth of the beam, in inches.

L = the span of the beam, in feet.

(e) Restrained Members.

When beams, girders or trusses are subject both to reaction shear and end moment, due to full or partial end restraint, or to continuous or cantilever construction, their connections shall conform to the requirements of Section 12(b).

(f) Fillers.

In riveted construction, when rivets carrying computed stress pass through fillers, the fillers shall be extended beyond the connected member and the extension secured by enough rivets to distribute the total stress in the member uniformly over the combined sections of the member and filler.

Fillers under the stiffeners on riveted plate girders, at end bearings or at points of concentrated loads, shall be secured by sufficient rivets to prevent excessive bending and bearing stresses.

In welded construction, when a filler is used between two parts connected in shear, there shall be sufficient welding to transfer the shearing stress from one part to the filler and from the filler to the other part. Fillers of less than ¼ inch thickness shall not be used to transfer stress, but shall be trimmed flush with the welded edges of the stress-carrying element and the sizes of the welds along the edges shall be increased over the required sizes by an amount equal to the thickness of the filler.

(g) Connections of Tension and Compression Members in Trusses.

The connections at ends of tension or compression members in trusses shall either develop the full effective strength of the material, or they shall develop the strength required by the total stresses; but in no case shall such strength developed be less than 50 percent of the effective strength of the material connected.

(h) Milled Joints in Compression Members.

Where compression members are in full-milled bearing on base plates, and where full-milled tier-building columns are spliced, there shall be sufficient rivets, bolts or welds to hold all parts securely in place.

Where other compression members are spliced by full-milled bearing, the splice material and its riveting or welding shall be arranged to hold all parts in line and shall be proportioned for 50 percent of the computed stress.

All the foregoing joints shall be proportioned to resist any tension that would be developed by specified wind forces acting in conjunction with 75 percent of the calculated dead load stress and no live load, if this condition will produce more tension than with full dead load and live load applied.

(i) Combinations of Welds.

If two or more of the general types of weld (butt, fillet, plug, slot) are combined in a single joint, the effective capacity of each shall be separately computed with reference to the axis of the group, in order to determine the allowable capacity of the combination.

Section 22. RIVETS AND BOLTS.

(a) Diameter.

In proportioning and spacing rivets, the nominal diameter of the undriven rivet shall be used.

(b) Effective Bearing Area.

The effective bearing area of pins, bolts, and rivets shall be the diameter multiplied by the length in bearing; except that for countersunk rivets half the depth of the countersink shall be deducted.

(c) Double and Single Shear Bearing.

Only that portion of a rivet or bolt shall be considered in double shear bearing, which lies between two portions which share the reaction therefrom. The remainder of the rivet or bolt shall be considered in single shear bearing.

(d) Long Grips.

Rivets which carry calculated stress, and the grip of which exceeds five diameters, shall have their number increased 1 percent for each additional $\frac{1}{16}$ inch in the rivet grip. Special care shall be used in heating and driving such rivets.

(e) Unfinished Bolts.

If unfinished bolts are provided with washers under nuts, and have unthreaded shanks extending completely through the joined parts, the shearing and bearing values elsewhere prescribed for unfinished bolts may be increased one-eighth.

Section 23. SPACING OF RIVETS.

(a) Minimum Pitch.

The minimum distance between centers of rivet holes shall preferably be not less than three times the diameter of the rivet.

(b) Maximum Pitch in Compression Members.

The maximum pitch in the line of stress of compression members composed of plates and shapes shall not exceed 16 times the thickness of the thinnest outside plate or shape, nor 20 times the thickness of the thinnest enclosed plate or shape, with a maximum of 12 inches.

At right angles to the direction of stress, the distance between lines of rivets shall not exceed 32 times the thickness of the thinnest plate where there is more than one ply. For angles in built-up sections with two gage lines, with rivets staggered, the maximum pitch in the line of stress in each gage line shall not exceed 24 times the thickness of the thinnest plate with a maximum of 18 inches.

(c) End Pitch in Compression Members.

The pitch of rivets at the ends of built compression members shall not exceed four diameters of the rivets for a length equal to 1½ times the maximum width of the member.

(d) Two-Angle Members.

In tension members composed of two angles, a pitch of 3′ 6″ will be allowed, and in compression members, 2′ 0″, but the ratio l/r for each angle between rivets shall be not more than ¾ of that for the whole member.

(e) Minimum Edge Distance.

The minimum distance from the center of any punched rivet hole to any edge shall be that given in Table I.

TABLE I

Rivet Diameter, Inches	Minimum Edge Distance (Inches) for Punched Holes		
	In Sheared Edge	In Rolled Edge of Plates	In Rolled Edge of Structural Shapes
½	1	⅞	¾*
⅝	1⅛	1	⅞*
¾	1¼	1⅛	1 *
⅞	1½	1¼	1⅛*
1	1¾	1½	1¼*
1⅛	2	1¾	1½*
1¼	2¼	2	1¾*

* May be decreased ⅛ inch when holes are near end of beam.

(f) Minimum Edge Distance in Line of Stress.

The distance from the center of any rivet under computed stress, and that end or other boundary of the connected member toward which the pressure of the rivet is directed, should be not less than the shearing area of the rivet shank (single or double shear respectively) divided by the plate thickness.

This end distance may however be decreased in such proportion as the stress per rivet is less than that permitted under Section 15 (a); and the requirement may be disregarded in case the rivet in question is one of three or more in line parallel to the direction of stress.

(g) Maximum Edge Distance.

The maximum distance from the center of any rivet to the near edge shall be 12 times the thickness of the plate, but shall not exceed 6 inches.

Section 24. WELDS.

(a) Types of Welds.

Butt, fillet, plug or slot welds, or a combination of these types, may be used in making joints and joining component parts.

(b) Qualification of Weld Details.

The details of all joints (including for butt welds the groove form, root face, root spacing, etc.) to be employed under this specification without qualification shall comply with all of the requirements for joints which are accepted without qualification test under the "Code for Arc and Gas Welding in Building Construction" of the American Welding Society. No joint form not included in the foregoing shall be employed until it shall have been qualified to the satisfaction of the Engineer in accordance with the "Standard Qualification Procedure" of the American Welding Society.

(c) Minimum Size of Fillet Welds.

The relation between weld size and the maximum thickness of material on which various sizes of fillet welds may be used shall, where practicable, conform to the following table:

Size of Fillet Inches	Maximum Thickness of Part Inches
3/16	½
¼	¾
5/16	1¼
⅜	2
½	6
⅝	Over 6

(d) Maximum Effective Size of Fillet Welds.

The maximum size of a fillet weld that may be assumed in the design of a connection shall be such that the stresses in the adjacent base material do not exceed the values allowed in Section 15 (a).

The maximum size fillet weld applied to a nominally square edge of plate or shape shall be 1/16 inch less than the nominal thickness of the edge, and the size of fillet weld used along the toe of an angle or the rounded edge of a flange shall not exceed three-fourths the nominal thickness of the angle leg or three-fourths the nominal edge thickness of the flange; except that when required by the design conditions and specially designated on the drawings, fillet welds equal in size to the edge of a plate or rolled section may be used, provided that the weld is built out in such a manner as to insure full throat thickness, full fusion area, and no injury to the base metal that will reduce its thickness adjacent to the weld.

(e) Length of Fillet Welds.

The minimum effective length of a strength fillet weld shall be not less than four times the nominal size, or else the size of the weld shall be considered not to exceed one-fourth of its effective length.

The effective length of any segment of intermittent fillet welding shall be not less than four times the weld size with a minimum of 1½ inches.

If longitudinal fillet welds are used alone in end connections, the length of each fillet weld shall be not less than the perpendicular distance between them.

(f) End Returns of Fillet Welds.

Side or end fillet welds terminating at ends or sides, respectively, of parts or members shall, wherever practicable, be returned continuously around the corners for a distance not less than twice the nominal size of the weld. This provision shall apply to side and top fillet welds connecting brackets, beam seats and similar connections, at the tension side of such connections, on the plane about which bending moments are computed. End returns shall be indicated on the design and detail drawings.

(g) Plug and Slot Welds.

Plug or slot welds, or fillet welds in holes or slots, may be used in plates not more than one inch thick, where subjected principally to shearing stresses or where needed to prevent buckling of lapped parts.

The diameter of the holes for plug weld and the width of slot welds shall be not less than the thickness of the part containing the hole or slot, plus 5/16 inch rounded to the net greater odd sixteenth. The diameter of plug welds and the width of slot welds shall not be greater than 3 times the thickness of the weld metal.

The maximum length of slot welds shall not exceed 10 times the thickness of the part containing the slot.

Section 25. SPACING OF WELDS.

(a) Longitudinal Fillet Welds.

The transverse spacing of longitudinal fillet welds used in end connections shall not exceed 8 inches, unless the design otherwise prevents excessive transverse bending in the connection.

(b) Intermittent Fillet Welds.

Intermittent fillet welds may be used to transfer calculated stress across a joint or faying surfaces when the strength required is less than that developed by a continuous fillet weld of the smallest practical size. The clear spacing in the direction of stress, between the effective lengths of such segments at the edges of plates and at the unsupported edges of rolled shapes carrying calculated stress, shall not exceed the following number times the thickness of the thinner part joined: for compression, 16; for tension, 24; and shall in no case be more than 12 inches. The effective length of longitudinal fillet welds at the ends of built-up members shall be not less than the width of the component part joined.

(c) Lap Joints.

The minimum width of laps, on lap joints, shall be five times the thickness of the thinner part joined and not less than 1 inch. Lap joints joining plates or bars subjected to axial stress shall be fillet welded along the edge of both lapped parts except where deflection of the lapped parts is sufficiently restrained to prevent opening of the joint under maximum loading.

(d) Slot Welds.

The clear distance from the edge of a slot to the adjacent edge of the slotted part, and the clear distance between adjacent slots, measured in a direction perpendicular to that of the main stress, shall be not less than five times the thickness of the slotted part nor less than twice the width of the slot.

(e) Stitch Welds.

If two or more plates or rolled shapes are used to build up a member, sufficient stitch welding (of the fillet, plug or slot type) to make the parts act in unison shall be provided as follows, except where transfer of calculated stress between the parts joined requires closer spacing.

1. For plates, the longitudinal clear spacing between stitch welds shall not exceed the provisions of paragraph (b) of this section and the transverse spacing shall not exceed 32 times the thickness of the thinner plate joined.
2. For members composed of two or more rolled shapes, in contact one with another, the longitudinal spacing of stitch welds shall not exceed 24 inches or the limits prescribed in (3).
3. For members composed of rolled shapes, separated one from the other by a gusset plate, the component parts shall be stitched together at intervals such that the critical ratio l/r, for each component, between stitching, shall not exceed three-fourths the critical ratio for the whole member.

Section 26. PLATE GIRDERS AND ROLLED BEAMS.

(a) Proportioning.

Riveted and welded plate girders, cover-plated beams, and rolled beams shall in general be proportioned by the moment of inertia of the gross section. No deduction shall be made for standard shop or field rivet holes in either flange; except that in special cases where the reduction of the area of either flange by such rivet holes, calculated in accordance with the provisions of Section 19, exceeds 15 percent of the gross flange area, the excess shall be deducted. If such members contain other holes, as for bolts, pins, countersunk rivets, or plug or slot welds, the full deduction for such holes shall be made. The deductions thus applicable to either flange shall be made also for the opposite flange if the corresponding holes are there present.

(b) Web.

Plate girder webs shall have a thickness of not less than 1/170 of the unsupported distance between flanges.

(c) Flanges.

The thickness of outstanding parts of flanges shall conform to the requirements of Section 18 (c).

Each flange of welded plate girders should in general consist of a single plate rather than two or more plates superimposed. The single plate may comprise a series of shorter plates, laid end to end and butt welded at their junctions.

Unstiffened cover plates on riveted girders shall not extend more than 16 times the thickness of the thinnest outside plate beyond the outer row of rivets connecting them to the angles. The total cross-sectional area of cover plates of riveted girders shall not exceed 70 percent of the total flange area.

If the girder is subjected to substantial fluctuations in loading, stiffeners, lateral plates or other appurtenant material shall not be welded to the tension flange, except at points where the maximum flange stress is less than half the allowable.

(d) Flange Development.

Rivets and welds connecting flange to web, or cover plates to flange, shall be proportioned to resist the maximum horizontal shear at the plane in question, resulting from the bending forces on the girder. Additionally, rivets and welds connecting flange to web shall be proportioned to transmit any loads applied directly to the flange.

(e) Stiffeners.

Bearing stiffeners shall be placed in pairs on the webs of plate girders at unframed ends and at points of concentrated loads. Such stiffeners shall have a close bearing against the loaded flanges, and shall extend as closely as possible to the edge of the flange plates or flange angles. They shall be designed as columns subject to the provisions of Section 15 (a); assuming the column section to comprise the pair of stiffeners and a centrally located strip of the web equal to not more than 25 times its thickness at interior stiffeners or a strip equal to not more than 12 times its thickness when the stiffeners are located at the end of the web. The column length shall be taken as not less than ¾ of the length of the stiffeners in computing the ratio l/r. Only that portion of the stiffener outside of the angle fillet or the flange-to-web welds shall be considered effective in bearing. Angle bearing stiffeners shall not be crimped.

If $\frac{h}{t}$ is equal to or greater than 70, intermediate stiffeners shall be required at all points where v exceeds $\frac{64{,}000{,}000}{(h/t)^2}$, in which

h = the clear depth between flanges, in inches.

t = the thickness of the web, in inches.

v = the greatest unit shear in the panel, in pounds per square inch, under any condition of complete or partial loading.

The clear distance between intermediate stiffeners, when stiffeners are required by the foregoing, shall not exceed 84 inches or that given by the formula.

$$d = \frac{11{,}000\,t}{\sqrt{v}}$$ where

d = the clear distance between stiffeners, in inches.

Intermediate stiffeners may be applied in pairs, one on each side of the web, or if preferred may alternate on opposite side of the web.

Intermediate angle stiffeners may be crimped over the flange angles. Intermediate stiffeners employed to stay the web plate against buckling, and not for the transfer of concentrated loads from flange to web, shall be of a section not less than that required by the formula

$I_s = 0.00000016\ H^4$, in which

H = total depth of web.

I_s = moment of inertia of the stiffeners or stiffener (figured with a common axis at the centerline of web for stiffeners in pairs and with the axis at the interface between stiffener and web for single stiffeners).

Rivets connecting stiffeners to the girder web shall be spaced not over 8 times their diameter, or more closely if so required in order to transmit the stress due to concentrated loads. If intermittent fillet welds are used, their spacing shall conform to the provisions of Section 25 (b).

(f) Splices.

Web splices in plate girders and in beams shall be proportioned to transmit the full shearing and bending stresses in the web at the point of splice. Web splices in welded girders shall preferably be complete penetration butt welds.

If the flanges are spliced, the splices shall either develop the full effective strength of the material or they shall develop the strength required by the total stresses, but in no case shall the strength developed be less than 50 percent of the effective strength of the material spliced, nor shall butt-welded joints be only partially welded.

(g) Horizontal Forces.

The flanges of plate girders supporting cranes or other moving loads shall be proportioned to resist the horizontal forces produced by such loads. (See Section 10 (d)).

(h) Web Crippling of Beams.

Rolled beams shall be so proportioned that the compressive stress at the web toe of the fillets, resulting from concentrated loads not supported by bearing stiffeners, shall not exceed the value of 24,000 pounds per square inch allowed in Section 15 (a). The governing formulas shall be

For interior loads $\frac{R}{t\,(N + 2k)}$ = not over 24,000

For end-reactions $\frac{R}{t\,(N + k)}$ = not over 24,000

where

R = concentrated interior load or end reaction, in pounds.

t = thickness of web, in inches.

N = length of bearing, in inches.

k = distance from outer face of flange to web toe of fillet, in inches.

Section 27. SEPARATORS.

(a) Separators.

Where two or more rolled beams or channels are used to form a girder, they shall be connected together at intervals of not more than 5 feet. Through-bolts and separators may be used provided that in beams having a depth of 12 inches or more, no fewer than 2 bolts shall be used with each separator. When concentrated loads are carried from one beam to the other, or distributed between the beams, diaphragms shall be used, designed with sufficient stiffness to distribute the load. Where beams are exposed, they shall be sealed against corrosion of interior surfaces, or spaced sufficiently far apart to permit cleaning and painting.

Section 28. TIE PLATES.

(a) Compression Members.

The open sides of compression members built up from plates or shapes shall be provided with lacing having tie plates at each end, and at intermediate points if the lacing is interrupted. Tie plates shall be as near the ends as practicable. In main members carrying calculated stress the end tie plates shall have a length of not less than the distance between the lines of rivets or welds connecting them to the segments of the member, and intermediate ones of not less than one-half of this distance. The thickness of tie plates shall be not less than one-fiftieth of the distance between the lines of rivets or welds connecting them to the segments of the members. In riveted construction, the rivet pitch in tie plates shall be not more than six diameters and the tie plates shall be connected to each segment by at least three rivets. In welded construction, the welding on each line connecting a tie plate shall aggregate not less than one-third the length of the plate.

(b) Tension Members.

Tie plates shall be used to secure the parts of tension members built up from plates or shapes. They shall have a length not less than two-thirds of the length specified for tie plates in compression members. Otherwise they shall conform to the requirements of Section 28 (a).

Section 29. LACING.

(a) Spacing.

Lacing bars (which term comprehends for the purposes of this Section flat bars, angles, channels or other shapes employed as lacing) of compression members shall be so spaced that the ratio l/r of the flange included between their connections shall be not over ¾ of the critical ratio for the member as a whole.

(b) Proportioning.

Lacing bars shall be proportioned to resist a shearing stress normal to the axis of the member equal to two percent of the total compressive stress in the member.

Lacing bars shall preferably be arranged in single system, for which the ratio l/r shall not exceed 140. For double lacing this ratio shall not exceed 200. Double lacing bars shall be joined at their intersections.

In determining the section required for lacing bars, the compression formula shall be used, l being taken as the unsupported length of the lacing bar between rivets or welds connecting it to the segments, for single lacing, and 70 percent of that distance for double lacing.

(c) Inclination.

The inclination of lacing bars to the axis of the member shall preferably be not less than 60 degrees for single lacing and 45 degrees for double lacing. When the distance between the lines of rivets or welds in the flanges is more than 15 inches, the lacing shall preferably be double or be made of angles.

(d) Perforated Cover Plates.

The function of tie plates and lacing may be assumed to be performed by the material in continuous cover plates perforated with a succession of access holes, the net width of which plates across holes is assumed available to resist axial stress, provided that: the ratio of length (in direction of stress) to width of hole shall not exceed 2; the clear distance between holes in the direction of stress shall be not less than the transverse distance between nearest lines of connecting rivets or welds; and the periphery of the holes at all points shall have a minimum radius of 1½ inches.

Section 30. CAMBER.

(a) Shown on Plans.

Cambering, if any, of trusses, beams or girders shall be called for on the design plans.

(b) Trusses and Girders.

Trusses of 80 feet or greater span should generally be cambered for approximately the dead load deflection. Crane girders of 75 feet or greater span should generally be cambered for approximately the dead and half live load deflection.

(c) Beams.

Specified camber for rolled beams over 15 inches in depth, shall be only that offered as cold cambering at the mill.

(d) Camber for Other Trades.

If camber is required in order to bring a loaded member into proper relation with the work of other trades, as for the attachment of runs of sash, the requirement shall be set forth on the plans and on the detail drawings.

(e) Erection.

Required camber of trusses shall be shown on the erection diagram. If camber involves the erection of any member under a straining force, this shall be noted on the erection diagram.

Section 31. COLUMN BASES.

(a) Loads.

Proper provision shall be made to transfer the column loads, and moments, if any, to the footings and foundations.

(b) Alignment.

Column bases shall be set level and to correct elevation with full bearing on the masonry.

(c) Finishing.

Column bases shall be finished to accord with the following requirements:

1. Rolled steel bearing plates, 2 inches or less in thickness, may be used without planing, provided a satisfactory contact bearing is obtained; rolled steel bearing plates, over 2 inches but not over 4 inches in thickness, may be straightened by pressing; or, if presses are not available, by planing on all bearing surfaces, to obtain a satisfactory contact bearing; rolled steel bearing plates, over 4 inches in thickness, shall be planed on all bearing surfaces (except as noted under 3).
2. Column bases other than rolled steel bearing plates shall be planed on all bearing surfaces (except as noted under 3).
3. The bottom surfaces of bearing plates and column bases which rest on masonry foundations and are grouted to insure full bearing contact need not be planed.

Section 32. ANCHOR BOLTS.

Anchor Bolts.

Anchor bolts shall be designed to provide resistance to all conditions of tension and shear at the bases of columns, including the net tensile components of any bending moments which may result from fixation or partial fixation of columns.

PART V. FABRICATION

Section 33. WORKMANSHIP.

(a) General.

All workmanship shall be equal to the best practice in modern structural shops.

(b) Straightening.

All material shall be clean and straight. If straightening or flattening is necessary, it shall be done by a process and in a manner that will not injure the material. Sharp kinks or bends shall be cause for rejection.

(c) Gas Cutting.

The use of a cutting torch is permissible if the metal being cut is not carrying substantial stress during the operation. Gas-cut edges which will be subjected to substantial tensile stress shall be cut by a mechanically-guided torch, or if hand cut shall be carefully examined and any nicks removed. The radii of re-entrant gas-cut fillets shall be as large as practicable, but never less than 1 inch. Edges and grooves may be prepared for welding by gas cutting, as defined in Section 33 (h).

(d) Planing of Edges.

Planing or finishing of sheared edges of plates or shapes, or of edges gas-cut with a mechanically guided torch, will not be required unless specifically called for on the drawings, or included in a stipulated edge preparation for welding.

(e) Riveted Construction—Holes.

Holes for rivets or unfinished bolts shall be $\frac{1}{16}$ inch larger than the nominal diameter of the rivet or bolt. If the thickness of the material is not greater than the nominal diameter of the rivet or bolt plus ⅛ inch, the holes may be punched. If the thickness of the material is greater than the nominal diameter of the rivet or bolt plus ⅛ inch, the holes shall be either drilled from the solid, or sub-punched and reamed. The die for all sub-punched holes, and the drill for all sub-drilled holes, shall be at least $\frac{1}{16}$ inch smaller than the nominal diameter of the rivet or bolt.

Drifting to enlarge unfair holes shall not be permitted. Holes that must be enlarged to admit the rivets shall be reamed. Poor matching of holes shall be cause for rejection.

Holes for turned bolts shall be drilled or reamed truly-cylindrical and not more than 1/50 inch larger than the external diameter of the bolt. Drilling or reaming for turned bolts shall be done after the parts to be connected are assembled; except that if such drilling or reaming after assembly is impracticable, it may be done through steel templets with hardened bushings.

(f) Riveted Construction—Assembling.

All parts of riveted members shall be well pinned or bolted and rigidly held together while riveting. Drifting done during assembling shall not distort the metal or enlarge the holes.

(g) Riveting.

Rivets shall be driven by power riveters, of either compression or manually-operated type, employing pneumatic, hydraulic or electric power. After driving they shall be tight and their heads shall be in full contact with the surface.

Rivets shall ordinarily be hot-driven, in which case their finished heads shall be of approximately hemispherical shape and shall be of uniform size throughout the work for the same size rivet, full, neatly finished and concentric with the holes. Hot-driven rivets shall be heated uniformly to a temperature not exceeding 1950° F.; they shall not be driven after their temperature has fallen below 1000° F.

Rivets may be driven cold if approved measures are taken to prevent distortion of the riveted material. The requirements for hot-driven rivets shall apply except as modified in the "Tentative Specifications for Cold-Driven Rivets" of the American Institute of Bolt, Nut and Rivet Manufacturers.

(h) Welded Construction—Preparation of Material.

Surfaces to be welded shall be free from loose scale, slag, rust, grease, paint and any other foreign material, except that mill scale which withstands vigorous wire brushing, may remain. A light film of linseed oil may be disregarded. Joint surfaces shall be free from fins and tears. Preparation of edges by gas cutting shall, wherever practicable, be done with a mechanically guided torch.

(k) Welded Construction—Assembling.

Parts to be fillet welded shall be brought in as close contact as practicable and in no event shall be separated more than $\frac{3}{16}$ inch. If the separation is $\frac{1}{16}$ inch or greater, the size of the fillet welds shall be increased by the amount of the separation. The separation between faying surfaces of lap joints shall not exceed $\frac{1}{16}$ inch. The fit of joints at contact surfaces which are not completely sealed by welds, shall be close enough to exclude water after painting.

Abutting parts to be butt welded shall be carefully aligned. Misalignments greater than ⅛ inch shall be corrected and, in making the correction, the parts shall not be drawn into a sharper slope than two degrees ($\frac{7}{16}$ inch in 12 inches).

The work shall be positioned for flat welding whenever practicable.

In assembling and joining parts of a structure or of built-up members, the procedure and sequence of welding shall be such as will avoid needless distortion and minimize shrinkage stresses. Where it is impossible to avoid high residual stresses in the closing welds of a rigid assembly, such closing welds shall be made in compression elements.

In the fabrication of cover-plated beams and built-up members, all shop splices in each component part shall be made before such component part is welded to other parts of the member.

(l) Welded Construction—Temperatures.

No welding shall be done when the temperature of the base metal is lower than 0° F. At temperatures between 32° F. and 0° F., the surface of all areas within three inches of the point where a weld is to be started, shall be heated to a temperature at least warm to the hand before welding is started.

When welds are being made in parts thicker than 1½ inches, the temperature of the base material adjacent to the welding shall be at least 70° F.

(m) Welding.

The technique of welding employed, the appearance and quality of welds made, and the methods used in correcting defective work shall conform to the "Code for Arc and Gas Welding in Building Construction" of the American Welding Society, Section 4—Workmanship.

All complete-penetration butt welds, except when produced with the aid of backing material or welded in the flat position from both sides in square-edge material not more than 5/16 inch thick with root opening not less than one-half the thickness of the thinner part joined, shall have the root of the initial layer gouged or chipped out on the back side before welding is started from that side, and shall be so welded as to secure sound metal and complete fusion throughout the entire intended cross section. Butt welds made with the use of a backing of the same material as the base metal shall have the weld metal thoroughly fused with the backing material. Backing strips may be removed by means of gas cutting, after welding is completed, provided no injury is done to the base and weld metal and the weld surface is left flush or slightly convex, with full throat thickness.

Incomplete-penetration butt welds shall be made with as nearly complete penetration and internal soundness as the formation of the joint and the method of welding will permit. (See Section 15 (f), final paragraph.)

To insure soundness, the ends of butt welds that carry stresses approaching the maximum allowable working stress shall be extended past the edges of the parts joined, by means of short extension bars providing a similar joint preparation and having a width not less than the thickness of the thicker part joined. Where the metal is not more than ¾ inch in thickness, the extension bars may be omitted if the ends of the butt weld are chipped or cut down to solid metal and side welds are applied to fill out the ends to the same reinforcement as the faces of the weld. If extension bars are removed upon completion of the weld, the ends of the weld shall be left smooth and flush with the edges of the abutting parts.

(n) Welded Construction—Peening.

Where required, multiple-layer welds may be peened with light blows from a power hammer, using an elongated round-nose tool. Peening shall be done after the weld has cooled to a temperature warm to the hand. Care shall be exercised to prevent scaling, flaking or cold working of weld and base metal from over-peening.

(o) Finishing.

Compression joints depending upon contact bearing shall have the bearing surfaces machined to a common plane after the members are completed.

(p) Lacing Bars.

The ends of lacing bars shall be neat and free from burrs.

(q) Tolerances.

Finished members shall be true to line and free from twists, bends and open joints.

Compression members may have a lateral variation not greater than 1/1000 of the axial length between points which are to be laterally supported.

A variation of 1/32 inch is permissible in the overall length of members with both ends milled.

Members without milled ends which are to be framed to other steel parts of the structure may have a variation from the detailed length not greater than 1/16 inch for members 30 feet or less in length, and not greater than ⅛ inch for members over 30 feet in length.

(r) Castings.

Steel castings shall be annealed.

Section 34. SHOP PAINTING.

(a) Shop Coat.

After inspection and approval and before leaving the shop, all steel work shall be thoroughly cleaned, by effective means, of all loose mill scale, rust, spatter, slag or flux deposit, oil, dirt and other foreign matter. Except where encased in concrete, and excepting edges and surface areas adjacent to edges, to be field welded, all steel work shall be given one coat of approved metal protection, applied thoroughly and evenly and well worked into the joints and other open spaces. All paint shall be applied to dry surfaces.

(b) Inaccessible Parts.

Parts inaccessible after assembly shall be given two coats of shop paint, preferably of different colors.

(c) Contact Surfaces.

Contact surfaces shall be cleaned, by effective means, before assembly, but not painted.

(d) Finished Surfaces.

Machine-finished surfaces shall be protected against corrosion by a suitable coating.

(e) Surfaces to be Field Welded.

Surfaces which are to be welded after erection shall where practicable not receive a shop coat of paint. If painted, such paint shall be removed before field welding, for a distance of at least 2 inches on either side of the joint.

Section 35. ADMINISTRATIVE PROVISIONS.

All of the Administrative Provisions contained in this Specification, preceding the Technical Provisions, are to be complied with under any contract invoking the Technical Provisions, unless and except as otherwise provided in the applicable Building Code or General Specifications.

LATEST REVISION, A.I.S.C. SPECIFICATION

SECTION 18. MINIMUM THICKNESS OF MATERIAL.*

General.

The minimum thickness required for protection against crippling, buckling, and shear are prescribed in Paragraphs (b) and (c) of this section and in Paragraph (b) of Section 26, respectively. Those stipulations assume that the material is straight and true as erected, within the limits prescribed in Section 33 (q), and is not reduced by corrosion.

No further stipulations as to minimum thickness shall apply to steelwork exposed to conditions no more seriously corroding than an indoor atmosphere controlled for human comfort, subject always to the requirements of Section 34 (a).

The following stipulations (1) and (2) as to minimum thickness shall apply to exterior steelwork enclosed in a non-impervious envelope or exposed to frequent rain or snow, and to interior steelwork subject to atmospheric exposure more corrosive than that mentioned in the preceding paragraph:

(1) Columns, studs, lintels, girders and beams; exterior trusses, exterior bracing members; one-fourth inch minimum.

(2) Purlins, girts, trusses and bracing members sheltered from direct exposure to rain and snow; three-sixteenths inch minimum.

The controlling thickness of rolled shapes, for the purposes of stipulations (1) and (2), shall be taken as the mean thickness of their flanges, regardless of web thickness.

Steelwork exposed to industrial fumes or vapor shall be given special protection as required in the judgment of the Engineer.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION

CODE OF STANDARD PRACTICE FOR STEEL BUILDINGS AND BRIDGES

AS ADOPTED 1924
REVISED DECEMBER 1, 1946

THIS DOCUMENT INCLUDES THE A. I. S. C. STANDARD PROPOSAL CONTRACT FORM AND STANDARD RELEASE AND INDEMNITY AGREEMENT

Section 1. GENERAL.

(a) Scope.

The rules and practices hereinafter defined are adopted by the American Institute of Steel Construction as standard for the industry and shall govern all conditions relating to the use of Class "A" Structural Steel, unless the contract between the Buyer and Seller specifies otherwise.

(b) Design, Fabrication and Erection.

Unless otherwise specified or required, the following Standard Specifications, as amended to date, shall apply: The Standard specification for the Design, Fabrication and Erection of Structural Steel for Buildings of the American Institute of Steel Construction, the Standard Specifications for Highway Bridges of the American Association of State Highway Officials, the Specifications for Steel Railway Bridges of the American Railway Engineering Association, or the Specifications for Welded Highway and Railway Bridges of the American Welding Society.

(c) Plans and Specifications for Bidding.

The plans shall show a complete design with sizes, sections and the relative location of various members with floor levels, column centers and offsets figured, and shall show the character of the work to be performed with sufficient dimensions to permit the making of an accurate estimate of cost. Plans shall be made to scale not less than ⅛ inch to the foot, and large enough to convey the information adequately.

Wind bracing and special details when required shall be shown in sufficient detail regarding rivets, welds and construction to permit an accurate estimate of cost.

(d) Responsibility for Design and Erection.

If the design, plans and specifications are prepared by the Buyer, the Seller shall not be responsible for the suitability, strength and rigidity of design, nor for the practicability or safety of erection when the erection is not done by the Seller.

(e) Patented Devices.

The Seller shall not be responsible for claims arising from the use of patented designs, devices or parts shown on the Buyer's plans or called for by the specifications furnished by the Buyer, but the Seller shall protect the Buyer against claims arising from the use of patented designs, devices or parts proposed by the Seller.

Section 2. CLASSIFICATION.

Class "A" Structural Steel.

Contracts taken to furnish the structural steel for buildings or bridges are based on furnishing the following items only:

Anchors for structural steel
Bases of steel or iron
Beams, purlins, and girts
Bearing plates for structural steel
Bearing shoes for bridges
Brackets made of structural steel
Bridge pins
Bridge railings of rolled structural steel
Checkered floor plates connected to the steel frame
Columns of steel, iron or pipe, or cement filled pipe, and struts of structural steel or pipe

Counterweight boxes for bridges
Crane rails and stops
Door frames constituting part of exterior wall steel framing
Expansion joints
Girders
Grillage beams
Hangers of structural steel, if attached to the structural steel framing and shown on the framing plans.
Lintels shown on the framing plans or otherwise enumerated.
Marquees (structural frame only)
Monorail beams of standard structural shapes.

Rivets and bolts sold on a delivered basis for field connections, as follows:

1. The Seller shall furnish sufficient rivets of suitable size, plus at least 10 per cent to cover waste, for all field connections of steel to steel which are designated as riveted field connections.
2. The Seller shall furnish sufficient bolts of suitable size, plus 5 percent to cover waste, for all field connections of steel to steel which are designated to be bolted.
3. In cases where materials in excess of minimum requirements are furnished to provide for waste or loss, all unused material remaining after completion of the work shall be the property of the Seller and be returned to him.

Separators, angles, tees, clips, bracing and detail fittings in connection with structural steel frame
Suspended ceiling supports of structural shapes 3 inches or greater in depth.
Tie and sag rods
Trusses

Unless specifically agreed to as part of the contract steel or iron items which are essentially required for the assembly or erection of materials supplied by other trades will not be furnished, even though shown on the plans as being fastened to the structural steel.

Section 3. INVOICING.

When conditions make it possible to award contracts on a lump sum basis the confusion of determining weights will be avoided. Scale weights involve a variation which frequently leads to a compromise based on calculated weights.

The rules hereinafter established, while not giving exact weights, are the basis upon which the Seller will make a lump sum or a pound price bid and they eliminate the necessity of increased cost of shop drawings and other refinements of manufacture which would very materially increase costs if exact weights were required.

Weights.

The weight of steel shall be assumed as 0.2833 pound per cubic inch and that of cast iron as 0.2604 pound per cubic inch.

Structural steel and iron sold at a unit price per pound, hundred weight (100 pounds) or ton (2000 pounds) shall be invoiced on the calculated weights of shapes, plates, bars, castings, rivets, bolts, and weld metal based on the detailed shop drawings and shop bills of material which show actual dimensions of materials used* as follows:

Dimensions:

The weight will be figured on the basis of rectangular dimensions for all plates, and ordered overall length for all structural shapes from which the required material is cut, with no deductions for copes, clips, sheared edges, punchings, borings, milling or planing. When parts can be economically cut in multiples from material of larger dimension, the calculated weight shall be taken as that of the material from which the parts are cut. All the material shall be ordered as economically as possible in conformity with the suppliers' standards of cutting dimensions.

Over-run, as follows:

1. To the nominal, theoretical weight of all plates or slabs will be added one-half the allowance for over-weight, in accordance with the applicable table in Specification A-7 of the American Society for Testing Materials.
2. To the nominal theoretical weight of checkered plates will be added the allowance for over-weight in accordance with the published weights of the manufacturers.

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* This is based on the usual practice of ordering material from the rolling mills to the nearest available dimensions. When material, obtained from local sources, involves unusual waste, special terms of contract shall be agreed upon.

3. The calculated weights of castings shall be the weights determined from the detail drawings of the pieces including standard fillets for such pieces. To this an average over-run of 10 per cent shall be added.

Rivets, as follows:

1. The weight of shop rivets will be based on the weights shown in the following table:

Rivets ½″ in diameter 20 pounds per 100 rivets
Rivets ⅝″ in diameter 30 pounds per 100 rivets
Rivets ¾″ in diameter 50 pounds per 100 rivets
Rivets ⅞″ in diameter 100 pounds per 100 rivets
Rivets 1 ″ in diameter 150 pounds per 100 rivets
Rivets 1⅛″ in diameter 250 pounds per 100 rivets
Rivets 1¼″ in diameter 325 pounds per 100 rivets

2. Field rivets and bolts shall be invoiced at their actual weight.

Painting and Galvanizing:

A percentage of the theoretical weight of the material protected shall be added as follows:

One-half of 1 per cent for each shop coat of paint.
One-fourth of 1 per cent for each coat of oil.
3½ per cent for galvanizing by hot dipping.

Arc Welding Electrodes, as follows:

The weight of shop and field welds will be based on the gross weight of electrode required to lay the weld, calculated as follows:

1. For standard equal-leg fillet welds, the weights of electrodes shall be calculated in accordance with the following table.

WEIGHTS FOR STANDARD FILLET WELDS

Specified Weld Size Inches	Gross Electrode Required Lbs. Per Foot of Weld†	
	Continuous	Intermittent*
⅛	.08	.09
$\frac{3}{16}$	.15	.17
¼	.25	.28
$\frac{5}{16}$	.36	.40
⅜	.50	.55
½	.83	.91
⅝	1.25	1.40
¾	1.75	1.95
⅞	2.35	2.60
1	3.00	3.30

* Weld length less than 32 times the specified size.
† Net length as called for on the drawings, exclusive of starting and stopping ends.

2. For unequal-leg fillet welds, the weight corresponding to the smaller leg, in the above table, shall be multiplied by the ratio of the longer leg to the smaller leg.
3. For all groove welds, the weight of electrode shall be calculated by adding 100% to the weight based upon the net theoretical weld cross section and length. The net theoretical volume of a square groove weld with zero root opening will be calculated as if $\frac{1}{32}$″ open.

Section 4. DRAWINGS AND SPECIFICATIONS.

(a) To enable the Seller to enter properly upon the execution of the work the Buyer shall furnish the Seller within a time agreed to in the contract, a survey of the site or lot lines, together with a complete and full design of the bridge or of the structural steel frame definitely locating all openings, levels, etc.; and showing all material to be furnished by the Seller with such information as may be necessary for the completion of the shop drawings by the Seller. All such information and drawings shall be consistent with the original drawings and specifications. Any expense caused by changes or omissions in such information and drawings, referred to above shall be at the Buyer's expense.

(b) In case of discrepancies between the drawings and the specifications prepared by either the Seller or the Buyer, the specification shall govern for buildings, and the drawings shall govern for bridges; and in case of discrepancies between the scaled dimensions on the drawings and the figures written on them, the figures shall govern.

Should the Seller in the regular progress of his work find discrepancies in the information furnished by the Buyer, he shall refer such discrepancies to the Buyer before proceeding further with work which would be affected.

The Seller shall be reimbursed by the Buyer for damage resulting from changed manufacturing operation caused by delays.

(c) Shop drawings shall be made and submitted to the Buyer's representative who shall examine the same and in five days return them approved with such corrections as he may find necessary. They shall be corrected by the Seller if necessary and returned for the Buyer's file as finally approved. The Seller may proceed with shop work, but in so doing he shall assume responsibility for having properly made the corrections indicated by the Buyer.

No change shall be made on any approved drawing without the written authorization of the Buyer.

In addition to the set of blue prints of approved shop drawings for the Buyer's file as above referred to, the Buyer may require the Seller to furnish without cost to the Buyer, one additional set of shop drawing blue prints, but any further additional sets shall be paid for by the Buyer. All drawings of tracings made by the Seller for the execution of his work shall remain his property unless otherwise specifically agreed to.

(d) Shop Drawings prepared by the Seller and approved by a representative of the Buyer shall be deemed the correct interpretation of the work to be done, but do not relieve the Seller of responsibility for the accuracy of details.

(e) After the shop drawings have been "approved" or "approved as noted" by the authority designated in the contract, any changes required by said authority shall be made at the expense of the Buyer.

(f) When detailed shop drawings are furnished by the Buyer no responsibility for misfits due to errors in the drawings will be assumed by the Seller.

Section 5. STOCK MATERIAL.

(a) Except as provided in paragraph (c), stock material shall be of a quality equal to that called for by the specifications of the American Society for Testing Materials for the classifications covering its intended use; and mill test reports shall constitute sufficient record as to the quality of material carried in stock. It is obviously impossible for the Seller to maintain records of heat or blow numbers of every piece of material in his stock, and the same shall not be required if all his stock purchases are made under an established specification as to grade and quality.

(b) Whenever a shop maintains such a practice in carrying a stock of material, it is deemed good practice to permit the use of such stock material in its fabricating operations whenever the shop desires to do so, instead of ordering items from the mill for a specific operation. Stock materials bought under no particular specifications or under specifications less rigid than those mentioned above, or stock material which has not been subject to mill or other recognized test reports, shall not be used, except as noted in paragraph (c), without the approval of the Buyer and then only under rigid inspection.

(c) It is permitted to use unidentified stock, material free from surface imperfections for short sections of minor importance or for small unimportant details, where the quality of the material could not affect the strength of the structure.

Section 6. INSPECTION AND DELIVERY.

(a) Test of Materials.

The Seller shall furnish mill test reports without charge, when so instructed in writing by the Buyer prior to the placing of mill orders. All other tests of materials shall be made at the Buyer's expense and in accordance with standard methods.

(b) Inspection.

The Seller's shop service includes inspection by his own inspectors, and shop or mill inspection other than this shall be paid for by the Buyer, in which case the Seller shall afford, without charge, facilities for the inspection of materials and workmanship.

(c) Acceptance of Materials.

When material is inspected by a representative of the Buyer at the Shop, the acceptance of such material by the Buyer's representative shall be considered the Buyer's final approval; but the Seller shall be responsible for the accuracy of the work and for defective materials or workmanship which may be discovered and condemned within a reasonable time after its incorporation into the structure.

(e) Anchor Bolts.

All anchor or foundation bolts, expansion bolts, cinch bolts or other connections between the work to be performed by the Seller and the work of other trades shall be located and set by the Buyer.

(f) Working Room.

The erection contractor shall be entitled to sufficient space at the site of the structure at a place convenient to him to place his derricks and other equipment necessary for erection. When conditions at the site provide working space not occupied by the structure, the erection contractor shall be entitled to storage space for sufficient material to keep his working force in continuous operation.

(g) Plumbing Up.

The temporary guys, braces and falsework or cribbing shall be the property of the Seller, and if after the steel has been plumbed and leveled, the work of completing the structure by other contractors is suspended or delayed, the Seller shall receive reasonable compensation for its use. Guys and braces that must be left after the steel has been plumbed shall be removed by the Buyer at his expense, and returned to the Seller in good condition.

Immediately upon completion by the steel erector, the Buyer shall assure himself, by whatever agencies he may elect, that the steel erector's work is plumb, level, and properly guyed, and that all lintels attached without provision for adjustment are in their proper location. If these conditions have not been complied with, he should immediately notify the erector and direct him to perfect his work. After the steel erector has braced, guyed and plumbed the work once to the satisfaction of the Buyer, his responsibility ceases. Any further work in bracing, guying or plumbing shall be performed entirely at the Buyer's expense.

In the setting or erecting of structural steel work for structures other than bridges, the individual pieces shall be considered plumb or level where the error does not exceed 1 to 500.

For exterior columns and columns adjacent to elevator shafts of multiple story building, the error from plumb shall not exceed 1 to 1000.

(h) Opportunity to Investigate Errors when Material is Sold Fabricated Only.

Correction of minor misfits and a reasonable amount of reaming or cutting will be considered as a legitimate part of erection. Any error in shop work which prevents the proper assembling and fitting up of parts by the moderate use of drift pins, or a moderate amount of reaming and slight chipping or cutting, shall be immediately reported to the Seller and his approval of the method of correction obtained.

(i) Wall and Bearing Plates.

All loose masonry bearing plates for beams, girders, lintels or trusses shall be set and grouted to grade and line by the Buyer, ready for the steel erector to set his work without unnecessary interruption or delay.

(j) Loose Lintels.

Loose lintels or pieces of all kinds and descriptions required by the design of a building to carry brick work over openings, and which can be set without a motor hoisting apparatus, and which lintels or pieces are not attached in any way to the rest of the steel structure, and cannot be placed except as the masonry work advances, will not be erected by the steel erector unless by special agreement.

(k) Elevator Framing for Buildings.

The settting or erection of guides, cars, machinery, cables, sheaves, pans, etc., for elevators, is not to be required of the steel erector.

(l) Field Assembling.

The size of assembled pieces of structural steel may be limited by the permissible weight and clearance dimensions of transportation. Unless otherwise directed by the Buyer, the Seller shall provide for such field connections as will require the least field work; and such field connections shall be a part of the erection work.

(m) Cutting, Drilling and Patching.

The Seller shall not be required to cut, drill or patch the work of others, or his own work for the accommodation of other trades, except at the Buyer's expense, unless such cutting, drilling or patching of the steel for the accommodation of other trades as shall be specified as part of the Seller's work shall be shown on the plans so that it may be done at the time of fabrication or paid for as extra work. The number, size and location of any tapped holes shall be given at the time of the signing of the contract or be paid for as extra work.

(n) Insurance.

1. Until completion and acceptance of his work the Seller shall maintain workmen's compensation insurance as may be required by law as well as the standard form of public liability insurance, in such limits as may be agreed upon between the Buyer and the Seller, protecting the Seller against claims for damages resulting from death of or injury to persons or destruction of property arising out of the Seller's negligent acts or omissions.

2. All other forms of insurance coverage such as fire, lightning, flood, earthquake or windstorm shall be provided by the Buyer, protecting the Seller against loss or damage to the work performed and material delivered at the site. All insurance covering such loss or damage shall be payable to the parties as their interests may appear.

3. In no event shall the Seller indemnify the Buyer against loss or expense other than by reason of and to the extent of the liability imposed by law upon the Seller for damages resulting from death of or injury to persons or destruction of property occasioned by the prosecution of the work.

(o) Temporary Floors for Buildings.

The Buyer shall provide plank, and cover all floors required by municipal or state laws, excepting the floor upon which the erecting derricks are located. This floor will be covered by the steel erector for working purposes.

(p) Painting.

The shop coat of paint is a priming coat and the Seller shall not be responsible for the condition of the paint after it has been delivered to the common carrier.

Unless specifically agreed, the field painting and the touching up of abrasions in the shop coat shall not be included in the contract.

(q) Final Cleaning Up.

Upon completion of erection and before final acceptance, the Seller shall remove all falsework, rubbish or temporary buildings furnished by him.

Section 8. DELAYS IN PROSECUTION OF WORK.

(a) Causes Beyond the Control of the Seller.

The Seller shall be excused for delays in the performance in whole or in part of his work resulting in whole or in part from any cause beyond the control of the Seller, including but not limited to fire, earthquake, flood, or windstorm; strikes, lockouts, or other differences with employees; or riots or embargoes; delays, losses, or damages in transportation; shortage of cars, fuel, labor, or materials. In case of the happening of any such cause of delay the time of completion shall be extended accordingly.

(b) Delays Caused by the Seller.

Should the Seller at any time, except as provided in the preceding paragraph, refuse or neglect to supply enough workmen of proper skill or material of proper quality, or to carry on the work with promptness and diligence, the Buyer, if not in default, may give the Seller ten days' written notice, whereupon, if the Seller continues to neglect the work, the Buyer may provide such labor or materials and deduct a reasonable cost from any money due or to become due the Seller under the contract, or may terminate the employment of the Seller under the agreement and take possession of the premises and of all materials, tools, and appliances thereon and employ any other person to finish the work. In the latter case, the Seller shall receive no further payment until the work be finished; then if the unpaid balance that would be due under the contract exceeds the cost to the Buyer of finishing the work, such excess shall be paid to the Seller, but if such cost exceeds unpaid balance, the Seller shall pay the excess to the Buyer.

(c) Delays Caused by the Buyer.

Should the Buyer fail to furnish the plans and other data described in Section 4 (a) at the time agreed, or should he delay or obstruct the work in any way so as to cause loss or damage to the Seller, he shall reimburse the Seller for such loss or damage.

Should the Buyer delay the fabrication or erection of the work for more than thirty (30) days at any time, the Seller may, upon five (5) days' written notice to the Buyer, terminate the contract and tender all undelivered material, whether worked or unworked, to the Buyer, who shall, upon transfer of title to such material, pay all cost or expense which the Seller shall have paid or be obligated to pay, together with all loss or damage to the Seller, including but not limited to, the value of all drawings prepared, materials purchased or fabricated, or shipped, stored, delivered, erected or in process of fabrication or erection, together with the value of the labor performed, and the loss of profits suffered by the Seller. Should the Buyer fail to accept such material, the Seller shall, at the expiration of such five (5) day period, in order to save the continuing storage and handling charges, proceed to sell all materials in his possession and control at not less than the then market value for scrap material and shall credit the sums received therefor against the amounts due from the Buyer as above set forth.

The contract price and contract dates of delivery and erection shall not be binding upon the Seller unless the Buyer shall provide the information and work to be performed by him at the times and in the manner agreed.

Section 9. EXTRA WORK.

(a) General.

Charges for extra work shall be made on a basis that is definitely and mutually agreed between the Buyer and the Seller at the time such extra expense arises.

In the absence of any such agreement between the Buyer and Seller, the following are listed as proper items to be included.

(b) Material.

All extra material required shall be invoiced at current warehouse prices, plus administrative overheads.* The sum of these charges shall be considered the actual cost, to which shall be added ten per cent for profit.

(c) Drafting Labor.

All extra labor in the drafting room shall be charged at actual cost as shown by the time cards, plus regular overheads.* The sum of these charges shall be considered the actual cost, to which shall be added ten per cent for profit.

(d) Shop Work.

All extra shop labor shall be charged at actual cost as shown by the time cards; to this shall be added the regular overheads.* The sum of these charges shall be considered the actual shop cost, to which shall be added ten per cent for profit.

(e) Field Work.

All extra labor required in the erection of structural steel shall be invoiced as follows:

The actual labor cost shall be that shown by the time cards, to which shall be added the cost of insurance at established rates, the cost of labor transportation when necessary, and an additional allowance for regular overheads.* The sum of these shall be considered the actual cost, to which shall be added ten per cent for profit.

Use of the Seller's equipment by the Buyer for work not included in the Seller's contract shall be billed at proper rental rates. Hoists for other trades employed on the structure shall be billed at a rate per hoist to be agreed upon.

(f) Miscellaneous.

Any additional cost, such as handling, hauling, painting, crating, freight, etc., shall be charged at actual cost, plus regular overheads.* The sum of these charges shall be considered the actual additional cost, to which shall be added ten per cent for profit.

(g) Overtime.

On contract work where the Seller has not agreed to work overtime, he shall not be required to do so without being paid for his extra expense and a profit.

(h) Extra Cleaning.

If because of continued storage, or for any other reason not the fault of the Seller, it becomes necessary to clean and repaint the steel work, the cost of this additional cleaning and painting shall be paid for as an extra, including regular overhead charges, plus ten per cent for profit.

Section 10. PROPOSALS AND CONTRACTS.

(a) Conflicts.

In the event of a conflict between the terms and conditions of the proposal, or contract, and the terms and conditions stated in the plans and specifications, the terms of the proposal or contract shall govern.

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* See A. I. S. C. Cost Manual.

(b) Price Adjustments Due to Changes in Plans.

Unit prices intended to apply to incidental changes made in the design drawings shall not apply after the material has been ordered at the mill. Changes in plans subsequent to the ordering of material shall be adjusted by mutual agreement in accordance with the principles of Section 9.

The Seller shall not be required nor expected to make the same unit prices for additions to as for deductions from the work included in the contract.

(c) Material Not Shown or Called For.

Clauses in the specification to the effect that all steel and iron items necessary to complete the structure shall be furnished by the Seller, whether or not they are shown on the plans or called for in the specifications, being obviously unfair, will not be recognized or subscribed to. The Seller shall, however, furnish all material and labor for details that may be required for such steel and iron work as is shown on the drawings or called for in the specification, although such details may themselves not be shown or called for.

(d) Items Not to be Furnished.

Unless specifically mentioned in the request for bids, or specifically agreed to, the bidders do not estimate or include the following items in their proposals:

Any charges for surety bonds or insurance not required by law, or any other general charge such as building permits, license fees or taxes for permission to work in city or state, engineering fees, removal of rubbish, cutting, patching or repairing of plaster or masonry work, office or telephone service, light, heat, fire insurance, or the erection of temporary structures, enclosures or stairs, and the like.

(e) Terms.

The following terms of payment are adopted as standard and shall govern in all cases, except when otherwise agreed to in the contract.

1. All payments shall be made in funds current at par in the Federal Reserve Bank District in which the principal office of the Seller is located.
2. For all materials for export, net cash in exchange for shipping documents shall be required.
3. For all materials to be erected by the Seller, the Buyer shall on the 10th day of each month pay an amount equal to not less than 90 per cent of the contract value of all materials shipped, stored or ready for shipment; and not less than 90 per cent of the contract value of the erection performed during the preceding month; and shall pay the remainder within 30 days after the completion of the steel contract; but the amount reserved by the Buyer shall at no time exceed double the contract value of the work remaining to be done.
4. For a contract on delivered work, terms shall be net cash for the contract value of each shipment; payment to be made on the 10th day of the month following shipments.
5. Should the Buyer fail to pay as agreed, then the Seller may suspend the work until such payment is made and satisfactory guarantee given that future payments will be made as agreed.
6. Unless otherwise agreed to, when material is sold delivered at, or freight is allowed to destination, the Buyer shall pay freight charges and the Seller shall accept receipted freight bills as cash to apply on matured payments due on or after arrival at destination of materials covered by such freight expense bills.
7. Payments shall all be considered to be due and shall be paid at the time specified, regardless of the final settlement for the structure as a whole, or for the work of any other trade; and when the contract is with a general contractor the payment for steel shall not be delayed by such general contractor pending his receiving estimates of payments from the owner.
8. Amounts past due shall bear interest at the maximum lawful rate.

PART IV

GENERAL DESIGN INFORMATION

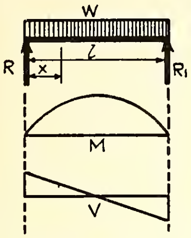
BEAM FORMULAE

SIMPLE BEAMS, SUPPORTED AT EACH END

R–R₁ = Reactions
V = Shear
M = Moment
D = Deflection
E = Modulus of Elasticity
I = Moment of Inertia

Deflection Data Given For Steel Beams Only

UNIFORM LOAD ①



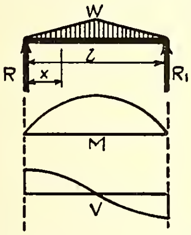
$R = R_1 = V_M = \frac{W}{2}$ $V_x = \frac{W}{2} - \frac{Wx}{l}$

$M_M = \frac{Wl^2}{8}$ $M_x = \frac{Wx}{2l}(l-x)$

D_M at center $= \frac{5}{384}\,\frac{Wl^3}{EI}$

$D_x = \frac{Wx}{24EIl}(l^3 - 2lx^2 + x^3)$

LOAD INCREASING UNIFORMLY TO CENTER ②



$R = R_1 = V_M = \frac{W}{2}$

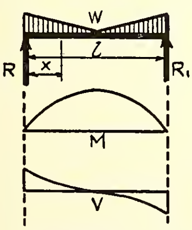
$V_x = \frac{W}{2} - \frac{2Wx^2}{l^2}$

$M_M = \frac{Wl}{6}$ $M_x = Wx\left(\frac{1}{2} - \frac{2x^2}{3l^2}\right)$

D_M at center $= \frac{Wl^3}{60EI}$

$D_x = \frac{Wx}{6EIl^2}\left(\frac{l^2x^2}{2} - \frac{x^4}{5} - \frac{5l^4}{16}\right)$

LOAD DECREASING UNIFORMLY TO CENTER ③



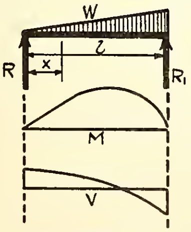
$R = R_1 = V_M = \frac{W}{2}$

$V_x = \frac{W}{2l^2}(l - 2x)^2$

$M_M = \frac{Wl}{12}$ $M_x = Wx\left(\frac{1}{2} - \frac{x}{l} + \frac{2x^2}{3l^2}\right)$

D_M at center $= \frac{3Wl^3}{320EI}$

LOAD INCREASING UNIFORMLY TO ONE END. ④



$R = \frac{W}{3}$ $R_1 = V_M = \frac{2W}{3}$

$V_x = \frac{W}{3} - \frac{Wx^2}{l^2}$

M_M at x, when $x = \frac{l\sqrt{3}}{3} = \frac{2Wl}{9\sqrt{3}} = 0.128Wl$

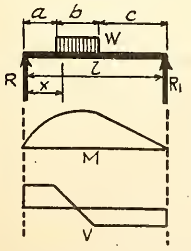
$M_x = \frac{Wx}{3}\left(1 - \frac{x^2}{l^2}\right)$

D_M at x, when $x = l\sqrt{1 - \sqrt{\frac{8}{15}}} = 0.519l$

$D_M = \frac{.013044Wl^3}{EI}$

$D_x = \frac{Wx}{6EIl^2}\left(\frac{x^4}{10} - \frac{l^2x^2}{3} + \frac{7l^4}{30}\right)$

UNIFORM LOAD ON PART OF BEAM. ⑤



$R = \frac{W(2c+b)}{2l}$ $R_1 = \frac{W(2a+b)}{2l}$

$V_M = R$, when $a < c$; $= R_1$ when $a > c$

At x when $x > a$ or $< (a+b)$

$V = \frac{W(2c+b)}{2l} - \frac{W}{b}(x-a)$

M_M at x, when $x = a + \frac{Rb}{W}$

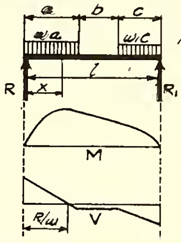
$M_M = \frac{W(2c+b)[4al + b(2c+b)]}{8l^2}$

When $x < a$ or $= a$, $M = Rx$

When $x < (a+b)$ or $> a$, $M = Rx - \frac{W(x-a)^2}{2b}$

When $x > (a+b)$, $M = Rx - \frac{W(2x-2a-b)}{2}$

UNIFORM LOADS PARTIALLY DISTRIBUTED AT ENDS ⑥



$R = V = \frac{wa(2l-a) + w_1c^2}{2l}$

$R_1 = V_1 = \frac{w_1c(2l-c) + wa^2}{2l}$

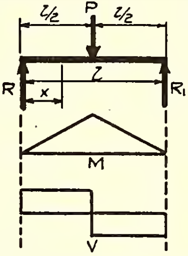
$V_x = R - wx$ (when $x < a$); $= R - R_1$ [when $x > a$ and $< (a+b)$]; $= R_1 - w_1(l-x)$ [when $x > (a+b)$]

$M_M = \frac{R^2}{2w}$ (at $x = \frac{R}{w}$ when $R < wa$)

$= \frac{R_1^2}{2w_1}$ (at $x = l - \frac{R_1}{w_1}$ when $R_1 < w_1c$)

$M_x = Rx - \frac{wx^2}{2}$ (when $x < a$)

ONE CONCENTRATED LOAD AT CENTER. ⑦



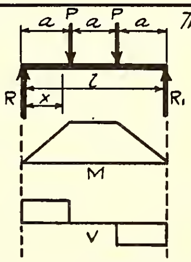
$R = R_1 = V_M = \frac{P}{2}$ $V_x = \frac{P}{2}$

$M_M = \frac{Pl}{4}$ at center. $M_x = \frac{Px}{2}$

D_M at center $= \frac{Pl^3}{48EI}$

When $x < \frac{l}{2}$, $D_x = \frac{P}{48EI}(3l^2x - 4x^3)$

TWO EQUAL CONCENTRATED LOADS AT $\frac{1}{3}$ POINTS. ⑧



$R = R_1 = V_M = P$

V_x when $x < a = P$

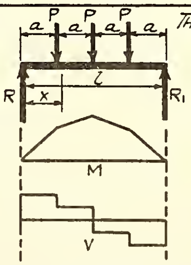
$M_M = \frac{2Pa}{2} = Pa.$ $M_x = \frac{2Px}{2} = Px.$

D_M at center $= \frac{2Pa}{12EI}\left(\frac{3l^2}{4} - a^2\right)$

D_x when $x < a = \frac{2Px}{12EI}(3la - 3a^2 - x^2)$

D_x when $x > a$ and $< (l-a) = \frac{2Pa}{12EI}(3lx - 3x^2 - a^2)$

THREE EQUAL CONCENTRATED LOADS AT $\frac{1}{4}$ POINTS. ⑨



$R = R_1 = V_M = \frac{3P}{2}$

V_x when $x < a = \frac{3P}{2}$

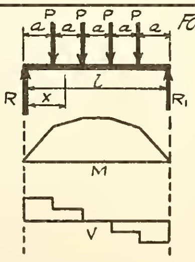
V_x when $x > a$ and less than $\frac{l}{2} = \frac{3P}{6}$

M_M at center $= \frac{3Pl}{6} = \frac{Pl}{2}$

M_x when $x = a$, $= \frac{3Pl}{8}$

D_M at center $= \frac{19}{384}\,\frac{3Pl^3}{3EI}$

FOUR EQUAL CONCENTRATED LOADS AT $\frac{1}{5}$ POINTS. ⑩



$R = R_1 = V_M = \frac{4P}{2}$

V_x when $x < a = \frac{4P}{2}$

V_x when $x > a$ and $< 2a = \frac{4P}{4} = P$

$M_M = \frac{4Pl}{6.67} = \frac{Pl}{1.67}$

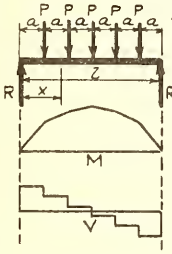
BEAM FORMULAE

SIMPLE BEAMS, SUPPORTED AT EACH END

$R-R_1$ = Reactions
V = Shear
M = Moment
D = Deflection
E = Modulus of Elasticity
I = Moment of Inertia

Deflection Data Given For Steel Beams Only

FIVE EQUAL CONCENTRATED LOADS AT $\frac{1}{6}$ POINTS. ⑪



$R = R_1 = V_M = \frac{5P}{2}$.

$V_x = \frac{5P}{2}$ when $x < a$

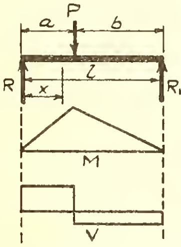
$V_x = \frac{3P}{2}$ when $x > a$ and $< 2a$

$V_x = \frac{P}{2}$ when $x > 2a$ and $< 3a$

V_M = Maximum Reaction.

$M_M = \frac{5Pl}{6\ 67} = \frac{Pl}{133}$

ONE CONCENTRATED LOAD NEAR ONE END. ⑫



$R = \frac{Pb}{l}$ $R_1 = \frac{Pa}{l}$

$V_M = R$ when $a < \frac{1}{2}l$, and R_1 when $a > \frac{1}{2}l$

$V_x = \frac{Pb}{l}$

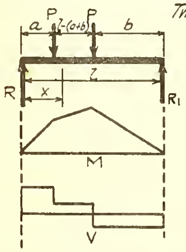
$M_M = \frac{Pab}{l}$ at point of load.

$M_x = \frac{Pbx}{l}$ when $x < a$

$D_M = Pab(a+2b)\sqrt{3a(a+2b)} \div 27EIl$, at x, when $x = \sqrt{a(a+2b) \div 3}$ and $a > b$

$D_x = \frac{Pbx}{6EIl}\left[2l(l-x) - b^2 - (l-x)^2\right]$ when $x < a$.

TWO EQUAL CONCENTRATED LOADS NEAR ONE END. ⑬



$R = \frac{P}{l}(l-a+b)$ $R_1 = \frac{P}{l}(l-b+a)$

V_M = Max. reaction. $V_x = R-P$, for x bet. loads

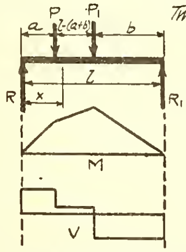
$M = Ra = \frac{Pa}{l}(l-a+b)$ at first load.

$M = R_1 b = \frac{Pb}{l}(l-b+a)$ at second load.

M_M = Greater of above.

$M_x = \frac{P}{l}(al-ax+bx)$ for x between loads.

TWO UNEQUAL CONCENTRATED LOADS UNSYMMETRICALLY LOCATED. ⑭



$R = \frac{1}{l}\left[P(l-a) + P_1 b\right]$ $R_1 = \frac{1}{l}\left[Pa + P_1(l-b)\right]$

V_M = Max. reaction. $V_x = R-P$ for x bet. loads.

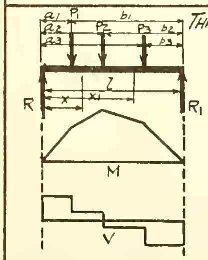
$M = Ra = \frac{a}{l}\left[P(l-a) + P_1 b\right]$ at P.

$M = R_1 b = \frac{b}{l}\left[Pa + P_1(l-b)\right]$ at P_1.

M_M = Greater of above.

$M_x = Pal(l-x) + P_1\frac{bx}{l}$ for x bet. loads.

THREE UNEQUAL CONCENTRATED LOADS UNSYMMETRICALLY LOCATED. ⑮



$R = \frac{\Sigma Pb}{l}$ $R_1 = \frac{\Sigma Pa}{l}$

$V_x = R - P_1$ $V_{x1} = R - P_1 - P_2$

V_M = Maximum reaction

$M = \frac{a_1}{l}\Sigma Pb$ at P_1; $M = \frac{a_2}{l}\Sigma Pb - P_1(a_2 - a_1)$ at P_2

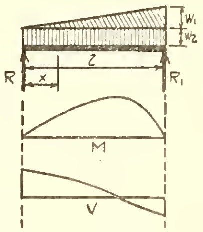
$M = \frac{b_3}{l}\Sigma Pa$ at P_3; M_M = Greater of above.

$M_M = M$ for P_1 if $P_1 > R$

$= M$ for P_2 if $P_1 < R$ when $(P_1+P_2) > R$

$= M$ for P_3 if $P_3 > R_1$

TRAPEZOIDAL LOAD TRIANGULAR PLUS UNIFORM LOAD. ⑯



$R = \frac{W_1 l}{6} + \frac{W_2 l}{2}$ $R_1 = \frac{W_1 l}{3} + \frac{W_2 l}{2} = V_M$

$V_x = \frac{W_1}{6l}(l^2 - 3x^2) + \frac{W_2}{2}(l-2x)$

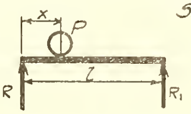
$M_M = \frac{l^2}{16}(2W_2 + W_1)$ Approx.

$M_x = \frac{W_2 x}{2}(l-x) + \frac{W_1 x}{6l}(l^2 - x^2)$

$D_M = \frac{5}{384}\frac{W_1 l^4}{EI} + 00652\frac{W_2 l^5}{EI}$

D_M at x, when $x = .5l$ approx.

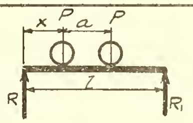
SINGLE CONCENTRATED MOVING LOAD. ⑰



$R = P = V_M$, when $x = 0$.

$M_M = \frac{Pl}{4}$ at P, when $x = \frac{l}{2}$

TWO EQUAL CONCENTRATED MOVING LOADS. ⑱

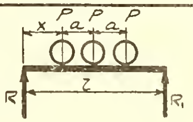


$V_M = P + P\frac{l-a}{2}$ at R, when $x = 0$

$M_M = P\frac{\left(l-\frac{a}{2}\right)^2}{2l}$ at x, when $x = \frac{1}{2}\left(l - \frac{a}{2}\right)$

When "a" exceeds 0 586l, use Case 17.

THREE EQUAL CONCENTRATED MOVING LOADS ⑲

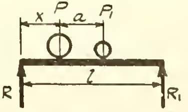


$V_M = 3P\frac{l-a}{2}$ at R, when $x = a$.

$M_M = P\left(\frac{3}{4}l - a\right)$ at $x+a$, when $x = \frac{1}{2}l$

When "a" exceeds 0 45l, M_M is found by Case 18.

TWO UNEQUAL CONCENTRATED MOVING LOADS. ⑳



$V_M = P + P_1\frac{l-a}{l}$ at R, when $x = 0$

$M_M = (P+P_1)\frac{x^2}{l}$ at P_1 when

$x = \frac{1}{2}\left[l - \frac{P_1 a}{P+P_1}\right]$

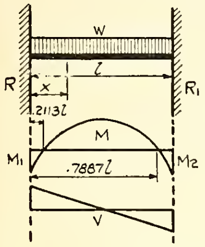
M_M may occur for one load as in Case 17.

BEAM FORMULAE

FULLY FIXED, AND FIXED ONE END ONLY

$R-R_1$ = Reactions
V = Shear
M = Moment
D = Deflection
E = Modulus of Elasticity
I = Moment of Inertia

Deflection Data Given For Steel Beams Only



UNIFORM LOAD

BOTH ENDS FIXED

㉑

$R = R_1 = V_M = \frac{W}{2}$

$V_x = \frac{W}{2} - \frac{Wx}{l}$

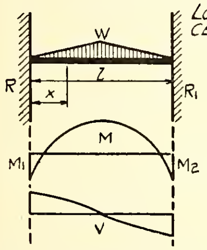
$M_1, M_2 = \frac{Wl}{12}$ at supports.

$M_M = \frac{Wl}{24}$ at center.

$M_x = \frac{W}{2l}\left(-\frac{l^2}{6} + lx - x^2\right)$

$D_M = \frac{1}{384}\frac{Wl^3}{EI}$ at center.

$D_x = \frac{Wx^2}{24EIl}(l^2 - 2lx + x^2)$



LOAD INCREASING UNIFORMLY TO CENTER: BOTH ENDS FIXED

㉒

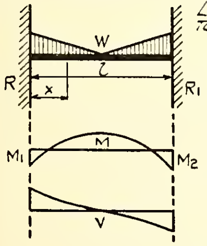
$R = R_1 = V_M = \frac{W}{2}$

$V_x = \frac{W}{2} - \frac{2Wx^2}{l^2}$

$M_M = \frac{Wl}{16}$ at center.

$M_1, M_2 = \frac{5Wl}{48}$ at supports.

$M_x = M_1 + \frac{Wx}{2} - \frac{2Wx^3}{3l^2}$



LOAD DECREASING UNIFORMLY TO CENTER. BOTH ENDS FIXED.

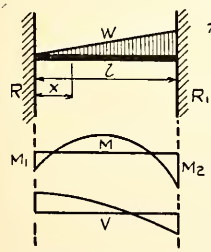
㉓

$R = R_1 = V_M = \frac{W}{2}$

$V_x = \frac{W}{2l^2}(l - 2x)^2$

$M_M = \frac{Wl}{48}$ at center.

$M_1, M_2 = \frac{Wl}{16}$ at supports.



LOAD INCREASING UNIFORMLY TO ONE END; BOTH ENDS FIXED.

㉔

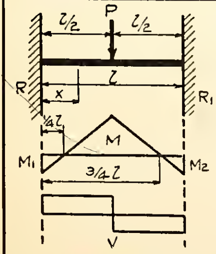
$R = \frac{3W}{10}$ $R_1 = V_M = \frac{7W}{10}$

$V_x = \frac{3W}{10} - \frac{Wx^2}{l^2}$

$M_M = .043Wl$ at x, when $x = .548l$.

$M_2 = \frac{Wl}{10}$

$M_x = \frac{3Wx}{10} - \frac{Wl}{15} - \frac{Wx^3}{3l^2}$.



ONE CONCENTRATED LOAD AT CENTER; BOTH ENDS FIXED

㉕

$R = R_1 = V_M = \frac{P}{2}$

$V_x = \frac{P}{2}$

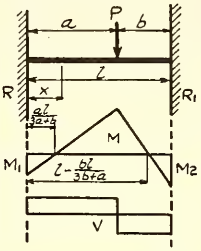
$M_M = \frac{Pl}{8}$ at center.

$M_1, M_2 = \frac{Pl}{8}$ at supports.

$M_x = \frac{P}{2}\left(x - \frac{l}{4}\right)$ at x, when $x < \frac{l}{2}$

$D_M = \frac{1}{192}\frac{Pl^3}{EI}$ at center.

$D_x = \frac{Px^2}{6EI}\left(-\frac{1}{2}x + \frac{3}{8}l\right)$



ONE CONCENTRATED LOAD NEAR END: BOTH ENDS FIXED

㉖

$R = P\left[\frac{b^2(3a+b)}{l^3}\right]$ $R_1 = P\left[\frac{a^2(3b+a)}{l^3}\right]$

*V_M = Greatest reaction.

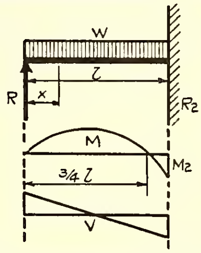
$M_M = Ra + M_1 = Ra - P\frac{ab^2}{l^2}$ at point of load

$M_x = Rx - P\frac{ab^2}{l^2}$

$M_1 = P\frac{ab^2}{l^2}$ at R.

$M_2 = P\frac{a^2b}{l^2}$ at R1.

$D_M = \frac{2Pa^3b^2}{3EI(3a+b)^2}$ at x, when $x = \frac{2al}{3a+b}$ and $a > b$



UNIFORM LOAD

ONE END FIXED, ONE SUPPORTED

㉗

$R = \frac{3}{8}W$, $R_1 = V_M = \frac{5}{8}W$

$V_x = \frac{3}{8}W - \frac{Wx}{l}$

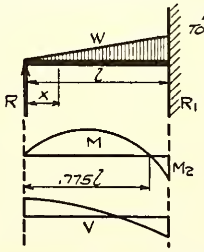
$M_M = \frac{9}{128}Wl$ at x, when $x = \frac{3}{8}l$

$M_x = \frac{Wx}{l}\left(\frac{3}{8}l - \frac{1}{2}x\right)$

$M_2 = \frac{1}{8}Wl$ at R_1 (fixed end)

$D_M = .0054\frac{Wl^3}{EI}$ at x, when $x = .4215l$.

$D_x = \frac{Wx}{48EIl}(-3lx^2 + 2x^3 + l^3)$



LOAD INCREASING UNIFORMLY TO FIXED END; OTHER SUPPORTED.

㉘

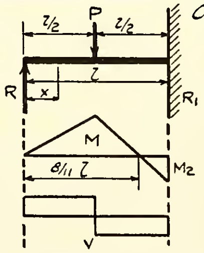
$R = \frac{1}{5}W$. $R_1 = V_M = \frac{4}{5}W$.

$V_x = \frac{W}{5} - \frac{Wx^2}{l^2}$

$M_M = .06Wl$ at x, when $x = .4474l$

$M_x = \frac{Wx}{5} - \frac{Wx^3}{3l^2}$

$M_2 = \frac{2Wl}{15} = .1333Wl$ at fixed end.



CONCENTRATED LOAD AT CENTER

ONE END FIXED, ONE SUPPORTED.

㉙

$R = \frac{5}{16}P$. $R_1 = V_M = \frac{11}{16}P$.

$M_M = \frac{5}{32}Pl$ at center.

$M_x = \frac{5}{16}Px$ when $x < \frac{l}{2}$

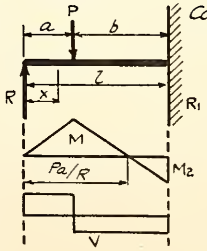
$M_x = \frac{1}{2}Pl - \frac{11}{16}Px$ when $x > \frac{l}{2}$

$M_2 = \frac{3}{16}Pl$ at fixed end.

$D_M = .00932\frac{Pl^3}{EI}$ at x, when $x = .4472l$.

$D_x = \frac{Px}{96EI}(5x^2 - 3l^2)$ when $x < \frac{l}{2}$.

$D_x = \frac{P}{96EI}(-2l^3 + 15l^2x - 24lx^2 + 11x^3)$ when $x > \frac{l}{2}$



CONCENTRATED LOAD AT ANY POINT

ONE END FIXED, ONE SUPPORTED

㉚

$R = P\left(\frac{3b^2l - b^3}{2l^3}\right)$ $R_1 = P\left(\frac{3al^2 - a^3}{2l^3}\right)$

$V = R$ at x, when $x < a$.

$V = R - P$ at x, when $x > a$.

$M_M = Pa\left(\frac{3b^2l - b^3}{2l^3}\right)$ at point of load.

$M_x = Px\left(\frac{3b^2l - b^3}{2l^3}\right)$ at x, when $x < a$.

$M_x = Px\left(\frac{3b^2l - b^3}{2l^3}\right) - P(x-a)$ when $x > a$.

$M_2 = Pl\left(\frac{3b^2l - b^3}{2l^3}\right) - P(l-a)$ at fixed end

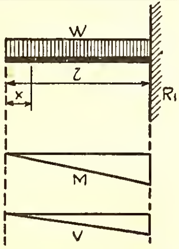
$D_M = .0098\frac{Pl^3}{EI}$ at x, when $x = a = .414l$

BEAM FORMULAE

CANTILEVER AND OVERHANGING BEAMS

$R-R_1$ = Reactions
V = Shear
M = Moment
D = Deflection
E = Modulus of Elasticity
I = Moment of Inertia

Deflection Data Given For Steel Beams Only



CANTILEVER BEAM
UNIFORM LOAD.

㉛

$R_1 = V_M = W$

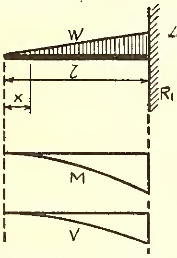
$V_x = \frac{Wx}{l}$

$M_M = \frac{Wl}{2}$

$M_x = \frac{Wx^2}{2l}$

$D_M = \frac{Wl^3}{8EI}$

$D_x = \frac{W}{24EIl}(x^4 - 4l^3 + 3l^4)$



CANTILEVER BEAM
LOAD INCREASING UNIFORMLY TO FIXED END

㉜

$R_1 = V_M = W$

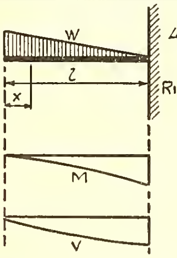
$V_x = \frac{Wx^2}{l^2}$

$M_M = \frac{Wl}{3}$

$M_x = \frac{Wx^3}{3l^2}$

$D_M = \frac{Wl^3}{15EI}$

$D_x = \frac{W}{60EIl^2}(x^5 - 5l^4x + 4l^5)$



CANTILEVER BEAM
LOAD INCREASING UNIFORMLY TO FREE END.

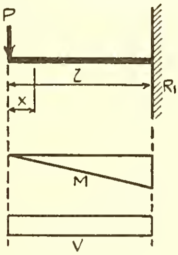
㉝

$R_1 = V_M = W$

$M_M = \frac{2Wl}{3}$

$M_x = \frac{Wx}{6l}(3l - x)$

$D_M = \frac{11}{120}\,\frac{Wl^3}{EI}$



CANTILEVER BEAM
CONCENTRATED LOAD AT FREE END.

㉞

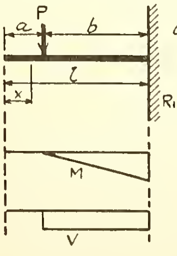
$R_1 = V_M = P \qquad V_x = P$

$M_M = Pl$

$M_x = Px$

$D_M = \frac{Pl^3}{3EI}$

$D_x = \frac{P}{6EI}(2l^3 - 3l^2x + x^3)$



CANTILEVER BEAM.
CONCENTRATED LOAD AT ANY POINT.

㉟

$R_1 = V_M = P$

$V_x = P$ when $x > a$

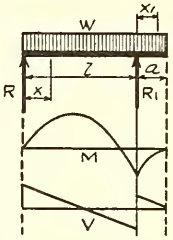
$M_M = Pb$

$M_x = P(x-a)$ when $x > a$

$D_M = \frac{Pl^3}{6EI}\left[2 - \frac{3a}{l} + \left(\frac{a}{l}\right)^3\right]$ at free end.

$D_x = \frac{P}{3EI}(l-a)^3$ at point of load.

$D_x = \frac{P}{6EI}(-3al^2 + 2l^3 + x^3 - 3ax^2 - 3l^2x + 6alx)$
at x, when $x > a$.



OVERHANGING ONE SUPPORT
UNIFORM LOAD.

㊱

$R = \frac{Wl}{2(l+a)} - \frac{Wa^2}{2l(l+a)} \qquad R_1 = \frac{Wl}{2(l+a)} + \frac{Wa}{l+a} + \frac{Wa^2}{2l(l+a)}$

$V = R - \frac{Wx}{l+a}$ when $x < l$.

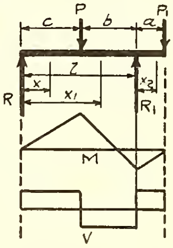
$V = \frac{W}{l+a}(a - x_1)$ when $x_1 < a$

$M_M = \frac{R^2(l+a)}{2W}$ at x, when $x = \frac{1}{2}\left(l - \frac{a^2}{l}\right)$

$M = \frac{Wa^2}{2(l+a)}$ at x, when $x = l$.

$M = Rx - \frac{Wx^2}{2(l+a)}$ at x_1, when $x_1 = \frac{W(a-x_1)^2}{2(l+a)}$

D_M at $x = \frac{1}{24EI}\left[4R(x^3 - l^2x) - \frac{W}{l+a}(x^4 - l^3x)\right]$



OVERHANGING ONE SUPPORT
CONC. LOADS, BET. SUPPORTS & AT FREE END

㊲

$R = \frac{Pb - P_1a}{l} \qquad R_1 = \frac{P(l-b) + P_1(a+l)}{l}$

$V = R$ at x, when $x < (l-b)$

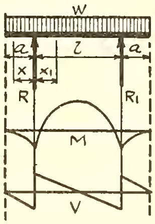
$V = R - P$ at x_1, when $x_1 > (l-b)$ and $< l$.

$V = P_1$ at x_2, when $x_2 < a$

$M = Rx$ at x, when $x < (l-b)$

$= Rx_1 - P(b + x_1 - l)$ at x_1, when $x_1 > (l-b)$

$= P_1(a - x_2)$ at x_e.



OVERHANGING BOTH SUPPORTS
UNIFORM LOAD.

㊳

$R = R_1 = \frac{W}{2}$

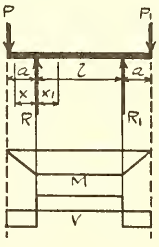
$V_M = \frac{Wa}{l+2a} \quad = \quad \frac{Wl}{2(l+2a)}$

$M = \frac{W(l-2a)}{8}$ at center.

$= \frac{Wa^2}{2(l+2a)}$ at supports.

$= \frac{W}{2(l+2a)}(a-x)^2$ at x, when $x < a$

$= \frac{W}{2(l+2a)}(a+x_1)^2 - Rx_1$, at x_1, when $x_1 < l$



OVERHANGING SYMMETRICAL SUPPORTS
EQUAL CONCENTRATED LOADS AT ENDS

㊴

$R = R_1 = V_M = P$ or P_1

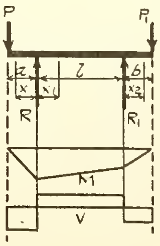
$V = P$ at x, when $x < a$.

$M_M = Pa$ at x_1 when $x_1 < l$

$M = P(a-x)$ at x when $x < a$

$D = \frac{(P+P_1)a^2(3l+2a)}{12EI}$ at free ends.

$D = \frac{(P+P_1)al^2}{16EI}$ at center.



OVERHANGING UNSYMMETRICAL SUPPORTS
CONCENTRATED LOADS AT ENDS.

㊵

$R = \frac{Pa - P_1b}{l} + P \qquad R_1 = \frac{P_1b - Pa}{l} + P_1$

$V = P$ at x, when $x < a$.

$V = P - R$ at x_1, when $x_1 < l$.

$V = P_1$ at x_2, when $x_2 < b$

$M = Pa$ at R. $\qquad M = P_1b$ at R_1.

$M = P(a-x)$ at x, when $x < a$

$M = Pa + (P-R)x_1$ at x_1, when $x_1 < l$

$M = P_1(b - x_2)$ at x_2, when $x_2 < b$

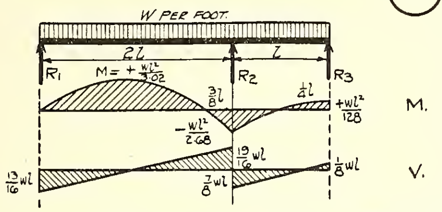
CONTINUOUS BEAMS

UNIFORM LOAD

SUPPORTED ENDS

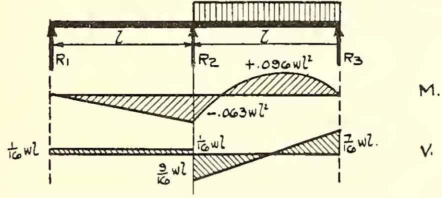
TWO SPANS, ONE TWICE THE OTHER IN LENGTH.

41


W PER FOOT.
2l
l
R1
R2
R3
M = + wl²/3.02
3/8 l
1/4 l
+wl²/128
-wl²/2.68
M.
19/16 wl
1/8 wl
13/16 wl
7/8 wl
V.

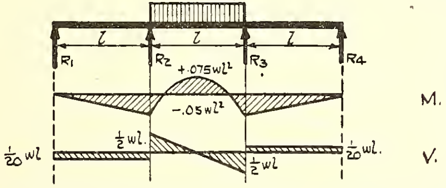
TWO EQUAL SPANS, ONE LOADED

42


W PER FOOT
l
l
R1
R2
R3
+.096wl²
-.063wl²
M.
1/16 wl
1/16 wl
7/16 wl.
9/16 wl
V.

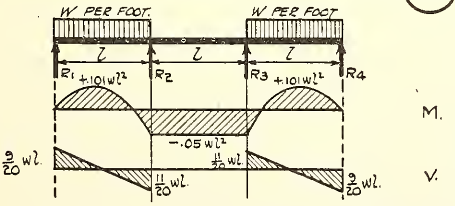
THREE EQUAL SPANS, CENTER SPAN LOADED

43


W PER FOOT
l
l
l
R1
R2
R3
R4
+.075wl²
-.05wl²
M.
1/2 wl.
1/20 wl
1/20 wl.
1/2 wl
V.

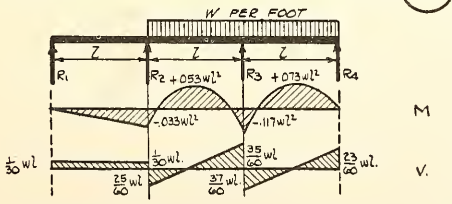
THREE EQUAL SPANS, END SPANS LOADED.

44


W PER FOOT.
W PER FOOT
l
l
l
R1
+.101wl²
R2
R3
+.101wl²
R4
M.
-.05wl²
9/20 wl.
11/20 wl.
11/20 wl.
9/20 wl.
V.

THREE EQUAL SPANS, ONE END SPAN UNLOADED.

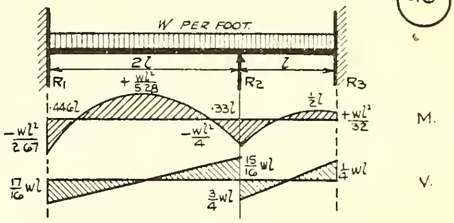
45


W PER FOOT
l
l
l
R1
R2
+.053wl²
R3
+.073wl²
R4
-.033wl²
-.117wl²
M
1/30 wl
1/30 wl.
35/60 wl
23/60 wl.
25/60 wl
37/60 wl.
V.

FIXED ENDS

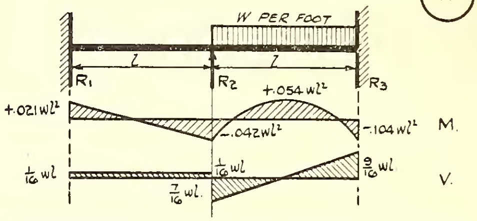
TWO SPANS, ONE TWICE THE OTHER IN LENGTH

46


W PER FOOT.
2l
l
R1
R2
R3
+ wl²/5.28
.446l
.33l
1/2 l
+wl²/32
-wl²/2.67
-wl²/4
M.
15/16 wl
1/4 wl
17/16 wl
3/4 wl
V.

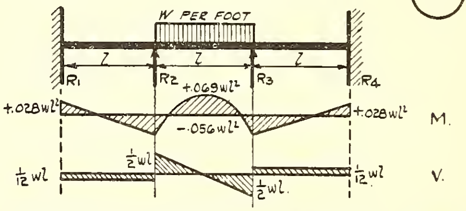
TWO EQUAL SPANS, ONE LOADED

47


W PER FOOT
l
l
R1
R2
R3
+.054wl²
+.021wl²
-.042wl²
-.104wl²
M.
1/16 wl
1/16 wl
9/16 wl
7/16 wl.
V.

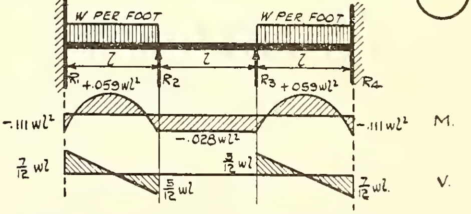
THREE EQUAL SPANS, CENTER SPAN LOADED

48


W PER FOOT
l
l
l
R1
R2
R3
R4
+.069wl²
+.028wl²
-.056wl²
+.028wl²
M.
1/2 wl
1/12 wl
1/12 wl
1/2 wl.
V.

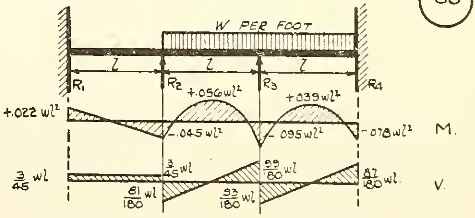
THREE EQUAL SPANS, END SPANS LOADED

49


W PER FOOT
W PER FOOT
l
l
l
R1
+.059wl²
R2
R3
+.059wl²
R4
-.111wl²
-.028wl²
-.111wl²
M.
7/12 wl
5/12 wl
5/12 wl
7/12 wl.
V.

THREE EQUAL SPANS, ONE END SPAN UNLOADED

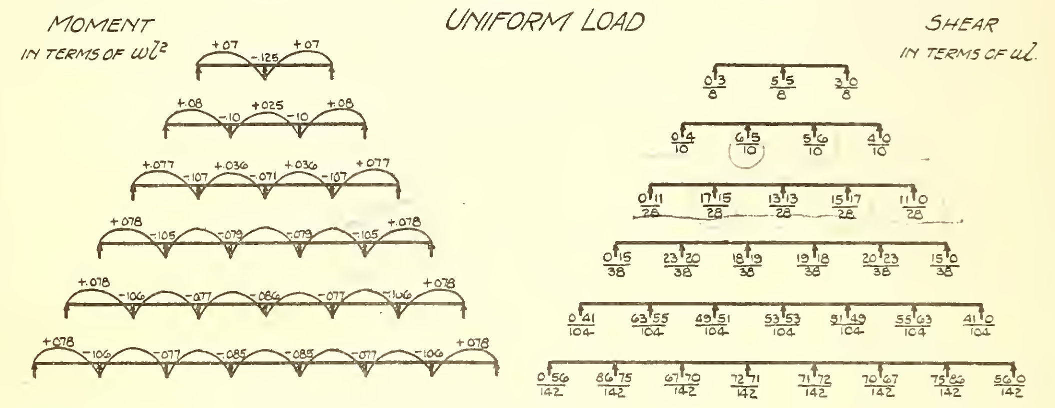
50

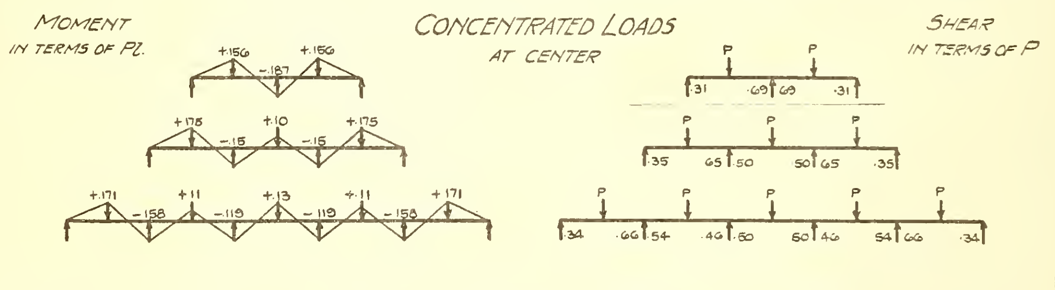

W PER FOOT
l
l
l
R1
R2
+.056wl²
R3
+.039wl²
R4
+.022wl²
-.045wl²
-.095wl²
-.078wl²
M.
3/45 wl
3/45 wl
99/180 wl
87/180 wl.
81/180 wl
93/180 wl
V.

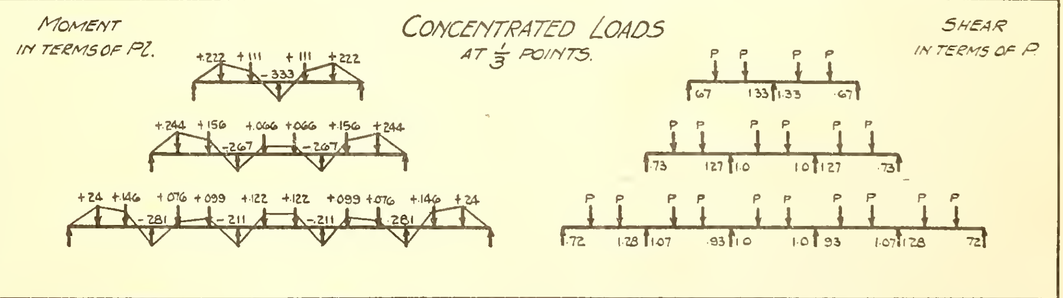
CONTINUOUS BEAMS

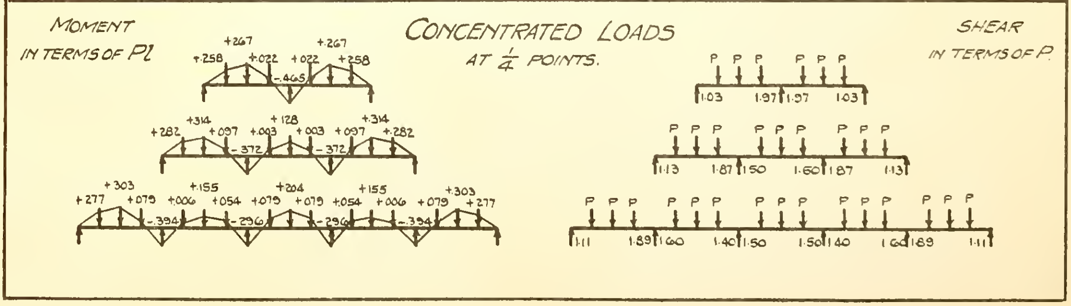
MOMENT AND SHEAR CO-EFFICIENTS

EQUAL SPANS, EQUALLY LOADED


MOMENT
IN TERMS OF wl^2
+.07 -.125 +.07
+.08 -.10 +.025 -.10 +.08
+.077 -.107 +.036 -.071 +.036 -.107 +.077
+.078 -.105 -.079 -.079 -.105 +.078
+.078 -.106 -.077 -.086 -.077 -.106 +.078
+.078 -.106 -.077 -.085 -.085 -.077 -.106 +.078
UNIFORM LOAD
SHEAR
IN TERMS OF wl.
$\frac{0\ 3}{8}$ $\frac{5\ 5}{8}$ $\frac{3\ 0}{8}$
$\frac{0\ 4}{10}$ $\frac{6\ 5}{10}$ $\frac{5\ 6}{10}$ $\frac{4\ 0}{10}$
$\frac{0\ 11}{28}$ $\frac{17\ 15}{28}$ $\frac{13\ 13}{28}$ $\frac{15\ 17}{28}$ $\frac{11\ 0}{28}$
$\frac{0\ 15}{38}$ $\frac{23\ 20}{38}$ $\frac{18\ 19}{38}$ $\frac{19\ 18}{38}$ $\frac{20\ 23}{38}$ $\frac{15\ 0}{38}$
$\frac{0\ 41}{104}$ $\frac{63\ 55}{104}$ $\frac{49\ 51}{104}$ $\frac{53\ 53}{104}$ $\frac{51\ 49}{104}$ $\frac{55\ 63}{104}$ $\frac{41\ 0}{104}$
$\frac{0\ 56}{142}$ $\frac{86\ 75}{142}$ $\frac{67\ 70}{142}$ $\frac{72\ 71}{142}$ $\frac{71\ 72}{142}$ $\frac{70\ 67}{142}$ $\frac{75\ 86}{142}$ $\frac{56\ 0}{142}$

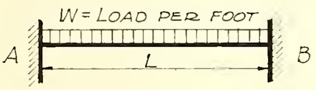
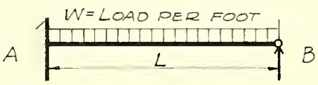
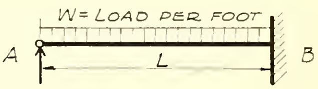
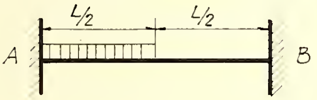
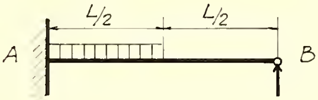
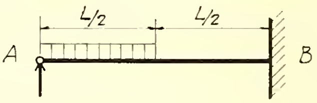
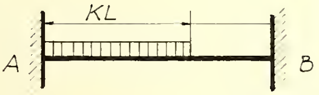
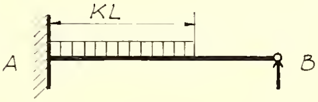
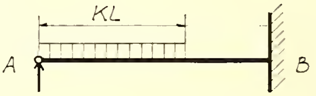
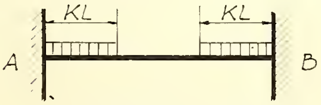
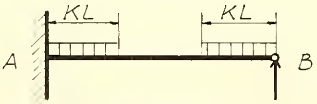
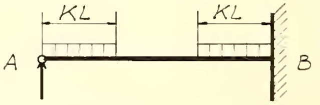
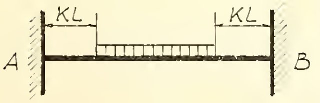
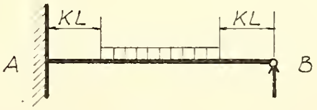
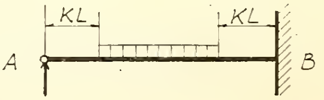
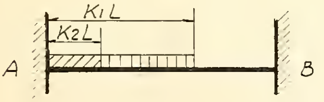
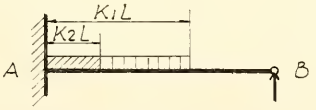
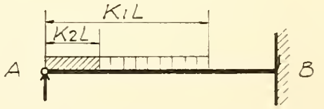

MOMENT
IN TERMS OF Pl.
+.156 -.187 +.156
+.175 -.15 +.10 -.15 +.175
+.171 -.158 +.11 -.119 +.13 -.119 +.11 -.158 +.171
CONCENTRATED LOADS
AT CENTER
SHEAR
IN TERMS OF P
P P
.31 .69 .69 .31
P P P
.35 .65 .50 .50 .65 .35
P P P P P
.34 .66 .54 .46 .50 .50 .46 .54 .66 .34


MOMENT
IN TERMS OF Pl.
+.222 +.111 +.111 +.222
-.333
+.244 +.156 +.066 +.066 +.156 +.244
-.267 -.267
+.24 +.146 +.076 +.099 +.122 +.122 +.099 +.076 +.146 +.24
-.281 -.211 -.211 -.281
CONCENTRATED LOADS
AT $\frac{1}{3}$ POINTS.
SHEAR
IN TERMS OF P.
P P P P
.67 1.33 1.33 .67
P P P P P P
.73 1.27 1.0 1.0 1.27 .73
P P P P P P P P P P
.72 1.28 1.07 .93 1.0 1.0 .93 1.07 1.28 .72


MOMENT
IN TERMS OF Pl
+.267 +.267
+.258 +.022 +.022 +.258
-.465
+.314 +.128 +.314
+.282 +.097 +.003 +.003 +.097 +.282
-.372 -.372
+.303 +.155 +.204 +.155 +.303
+.277 +.079 +.006 +.054 +.079 +.079 +.054 +.006 +.079 +.277
-.394 -.296 -.296 -.394
CONCENTRATED LOADS
AT $\frac{1}{4}$ POINTS.
SHEAR
IN TERMS OF P.
P P P P P P
1.03 1.97 1.97 1.03
P P P P P P P P P
1.13 1.87 1.50 1.60 1.87 1.13
P P P P P P P P P P P P P P P
1.11 1.89 1.60 1.40 1.50 1.50 1.40 1.60 1.89 1.11

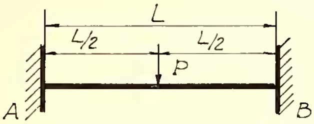
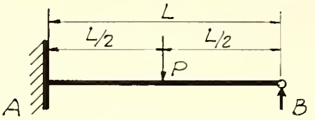
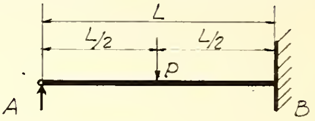
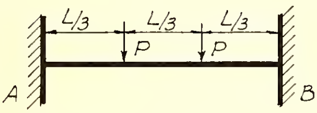
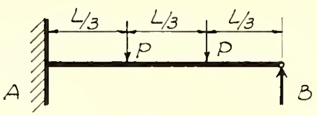
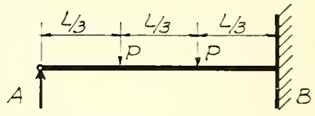
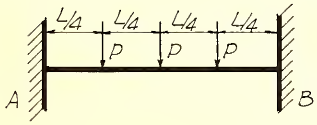
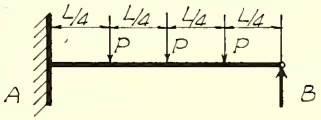
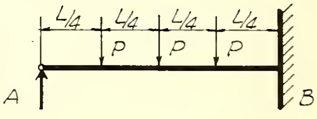
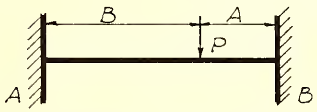
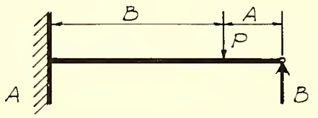
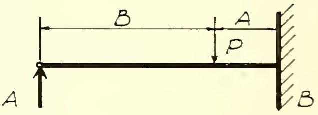
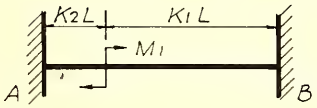
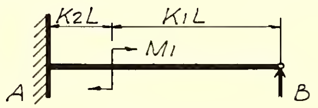
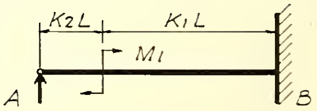
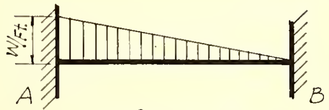
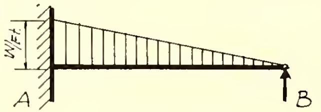
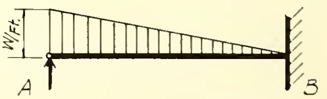
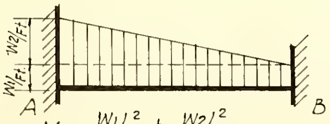
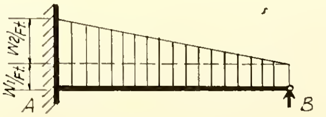
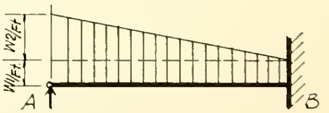
FIXED END MOMENTS
FOR PRISMATIC (CONSTANT INERTIA) BEAMS

It is understood that the conditions assumed in the examples—full fixity, full hinge, or both—are not those actually encountered. The values given are to serve as a basis for analysis by means of the Moment Distribution or similar methods of design analysis.

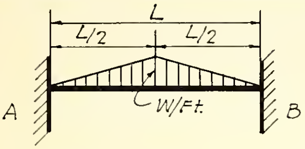
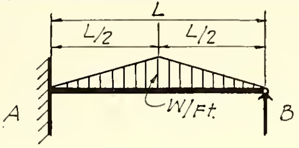
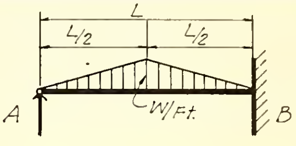
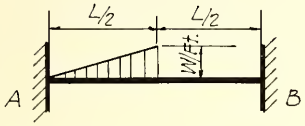
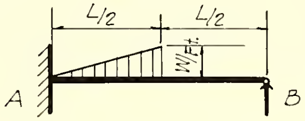
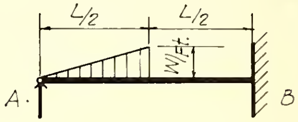
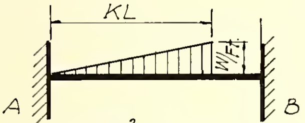
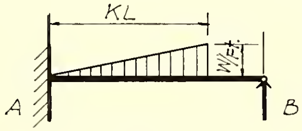
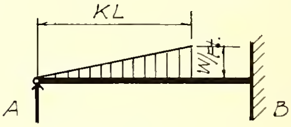
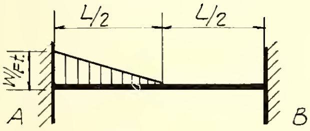
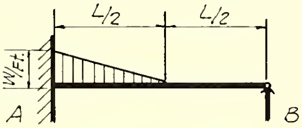
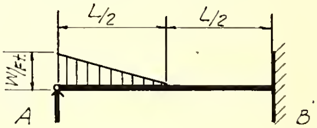
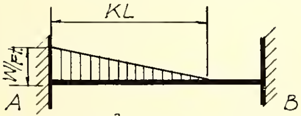
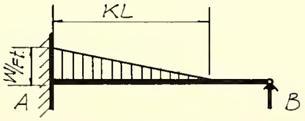
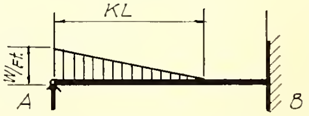
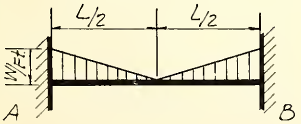
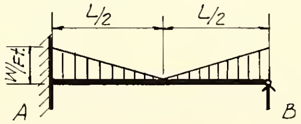
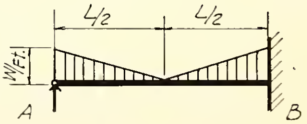
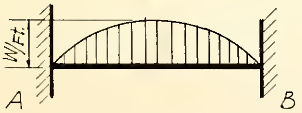
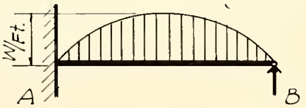
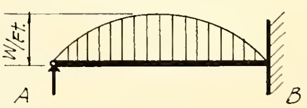
BEAM FIXED AT BOTH ENDS	LEFT END FIXED RIGHT END HINGED	LEFT END HINGED RIGHT END FIXED
 W = LOAD PER FOOT A L B $M_A = \frac{WL^2}{12}$ $M_B = M_A$	 W = LOAD PER FOOT A L B $M_A = \frac{WL^2}{8}$ $R_B = \frac{3}{8}WL$	 W = LOAD PER FOOT A L B $M_B = \frac{WL^2}{8}$ $R_B = \frac{5}{8}WL$
 $M_A = \frac{11}{192}WL^2$ $M_B = \frac{5}{192}WL^2$	 $M_A = \frac{9}{128}WL^2$	 $M_B = \frac{7}{128}WL^2$
 $M_A = \frac{WL^2}{12} \cdot K^2(6-8K+3K^2)$ $M_B = \frac{WL^2}{12} \cdot K^3(4-3K)$	 $M_A = \frac{WL^2K^2}{8}(4-4K+K^2)$	 $M_B = \frac{WL^2K^2}{8}(2-K^2)$
 $M_A = M_B = \frac{WL^2}{6} \cdot K^2(3-2K)$	 $M_A = \frac{WL^2}{4} \cdot K^2(3-2K)$	 $M_B = \frac{WL^2}{4} \cdot K^2(3-2K)$
 $M_A = M_B = \frac{WL^2}{12}(1-6K^2+4K^3)$	 $M_A = \frac{WL^2}{8}(1-6K^2-4K^3)$	 $M_B = \frac{WL^2}{8}(1-6K^2-4K^3)$
 $M_A = M_A(\text{For } K_1L) - M_A(\text{For } K_2L)$ $M_B = M_B(\text{For } K_1L) - M_B(\text{For } K_2L)$	 $M_A = M_A(\text{For } K_1L) - M_A(\text{For } K_2L)$	 $M_B = M_B(\text{For } K_1L) - M_B(\text{For } K_2L)$

$K = \frac{x}{l}$

FIXED END MOMENTS
FOR PRISMATIC (CONSTANT INERTIA) BEAMS

BEAM FIXED AT BOTH ENDS	LEFT END FIXED RIGHT END HINGED	LEFT END HINGED RIGHT END FIXED
 $M_A = M_B = \frac{PL}{8}$	 $M_A = \frac{3PL}{16}$	 $M_B = \frac{3PL}{16}$
 L/3 L/3 L/3 P P A B $M_A = M_B = \frac{2PL}{9}$	 L/3 L/3 L/3 P P A B $M_A = \frac{PL}{3}$	 L/3 L/3 L/3 P P A B $M_B = \frac{PL}{3}$
 L/4 L/4 L/4 L/4 P P P A B $M_A = M_B = \frac{15PL}{48}$	 L/4 L/4 L/4 L/4 P P P A B $M_A = \frac{45PL}{96}$	 L/4 L/4 L/4 L/4 P P P A B $M_B = \frac{45PL}{96}$
 $M_A = \frac{PA^2B}{L^2}$ $M_B = \frac{PB^2A}{L^2}$	 $M_A = \frac{P}{L^2}\left(A^2B + \frac{B^2A}{2}\right)$	 $M_B = \frac{P}{L^2}\left(B^2A + \frac{A^2B}{2}\right)$
 K2L K1L M1 A B $M_A = M_1K_1(1-3K_2) = M_1K_1(3K_1-2)$ $M_B = M_1K_2(1-3K_1) = M_1K_2(3K_2-2)$	 K2L K1L M1 A B $M_A = \frac{-M_1}{2}(3K_1^2-1)$	 K2L K1L M1 A B $M_B = \frac{+M_1}{2}(3K_2^2-1)$
 $M_A = \frac{WL^2}{20}$ $M_B = \frac{WL^2}{30}$ $R_A = 0.7(\frac{1}{2}WL)$ $R_B = 0.3(\frac{1}{2}WL)$	 $M_A = \frac{WL^2}{15}$ $R_A = 0.8(\frac{1}{2}WL)$ $R_B = 0.2(\frac{1}{2}WL)$	 $M_B = \frac{7WL^2}{120}$
 W2/Ft. W1/Ft. A B $M_A = \frac{W_1L^2}{12} + \frac{W_2L^2}{20}$ $M_B = \frac{W_1L^2}{12} + \frac{W_2L^2}{30}$	 W2/Ft. W1/Ft. A B $M_A = \frac{W_1L^2}{8} + \frac{W_2L^2}{15}$	 W2/Ft. W1/Ft. A B $M_B = \frac{W_1L^2}{8} + \frac{7W_2L^2}{120}$

FIXED END MOMENTS
FOR PRISMATIC (CONSTANT INERTIA) BEAMS

BEAM FIXED AT BOTH ENDS	LEFT END FIXED RIGHT END HINGED	LEFT END HINGED RIGHT END FIXED
 L L/2 L/2 W/Ft. A B $M_A = M_B = \frac{5WL^2}{96}$	 L L/2 L/2 W/Ft. A B $M_A = \frac{5WL^2}{64}$	 L L/2 L/2 W/Ft. A B $M_B = \frac{5WL^2}{64}$
 $M_A = \frac{WL^2}{30}$ $M_B = \frac{3WL^2}{160}$	 $M_A = \frac{41WL^2}{960}$	 $M_B = \frac{17WL^2}{480}$
 $M_A = \frac{WL^2}{30}\cdot K^2(10-15K+6K^2)$ $M_B = \frac{WL^2}{20}\cdot K^3(5-4K)$	 $M_A = \frac{WL^2K^2}{120}(40-45K+12K^2)$	 $M_B = \frac{WL^2K^2}{30}(5-3K^2)$
 $M_A = \frac{23WL^2}{960}$ $M_B = \frac{7WL^2}{960}$	 $M_A = \frac{53WL^2}{1920}$	 $M_B = \frac{37WL^2}{1920}$
 $M_A = \frac{WL^2}{60}\cdot K^2(10-10K+3K^2)$ $M_B = \frac{WL^2}{60}\cdot K^3(5-3K)$	 $M_A = \frac{WL^2}{120}\cdot K^2(20-15K+3K^2)$	 $M_B = \frac{WL^2}{120}\cdot K^2(10-3K^2)$
 $M_A = M_B = \frac{WL^2}{32}$	 $M_A = \frac{3WL^2}{64}$	 $M_B = \frac{3WL^2}{64}$
 $M_A = M_B = \frac{WL^2}{15}$	 $M_A = \frac{WL^2}{10}$	 $M_B = \frac{WL^2}{10}$

For Uniform Load:
$M = \text{Co-eff.} \times Wl$
For Concentrated Loads:
$M = \text{Co-eff.} \times Wl = \text{Co-eff.} \times \Sigma Pl.$

BENDING MOMENT CO-EFFICIENTS

For Uniform Loads and Equal Concentrated Loads
Latter Equally Spaced
Spans of Approximately Equal Length

IN TERMS OF EQUIVALENT UNIFORM LOAD OR TOTAL OF CONCENTRATED LOADS

Number of Equal Concentrated Loads	Number of Equal Spaces	SIMPLE BEAMS		2-SPAN CONTINUOUS BEAMS			3 OR MORE SPANS CONTINUOUS BEAMS					FULLY RESTRAINED CONTINUOUS BEAMS (See Note)									
		CO-EFFICIENTS		END SPAN			END SPAN			INTERIOR SPAN		END SPAN Lt. Cols.—Case 1			END SPAN Hv. Cols.—Case 2			INTERIOR SPAN	
		Center	End	Wall Sup.	Center	Inter. Sup.	Wall Sup.	Center	Inter. Sup.	Center	Sup.	Wall Sup.	Center	Inter. Sup.	Wall Sup.	Center	Inter. Sup.	Center	Sup.
		$+1/8$	$-1/24$	$-1/24$	$+1/10$	$-1/8$	$-1/24$	$+1/10$	$-1/10$	$+1/12$	$-1/12$	$-1/12$	$+1/12$	$-1/12$	$-1/16$	$+1/10$	$-1/10$	$+1/16$	$-1/12$
Uniform	Load =	.125	.042	.042	.100	.125	.042	.100	.100	.083	.083	.083	.083	.083	.063	.100	.100	.063	.083
1	2	.250	.084	.084	.200	.250	.084	.200	.200	.167	.167	.167	.167	.167	.125	.200	.200	.125	.167
2	3	.167	.056	.056	.133	.167	.056	.133	.133	.111	.111	.111	.111	.111	.083	.133	.133	.083	.111
3	4	.167	.056	.056	.133	.167	.056	.133	.133	.111	.111	.111	.111	.111	.083	.133	.133	.083	.111
4	5	.150	.050	.050	.120	.150	.050	.120	.120	.100	.100	.100	.100	.100	.075	.120	.120	.075	.100
5	6	.150	.050	.050	.120	.150	.050	.120	.120	.100	.100	.100	.100	.100	.075	.120	.120	.075	.100
6	7	.143	.048	.048	.114	.143	.048	.114	.114	.095	.095	.095	.095	.095	.072	.114	.114	.072	.095
7	8	.143	.048	.048	.114	.143	.048	.114	.114	.095	.095	.095	.095	.095	.072	.114	.114	.072	.095
8	9	.139	.047	.047	.111	.139	.047	.111	.111	.093	.093	.093	.093	.093	.070	.111	.111	.070	.093
9	10	.139	.047	.047	.111	.139	.047	.111	.111	.093	.093	.093	.093	.093	.070	.111	.111	.070	.093
10	11	.136	.046	.046	.109	.136	.046	.109	.109	.091	.091	.091	.091	.091	.068	.109	.109	.068	.091
11	12	.136	.046	.046	.109	.136	.046	.109	.109	.091	.091	.091	.091	.091	.068	.109	.109	.068	.091
12	13	.135	.045	.045	.108	.135	.045	.108	.108	.090	.090	.090	.090	.090	.068	.108	.108	.068	.090
13	14	.135	.045	.045	.108	.135	.045	.108	.108	.090	.090	.090	.090	.090	.068	.108	.108	.068	.090
14	15	.134	.045	.045	.107	.134	.045	.107	.107	.089	.089	.089	.089	.089	.067	.107	.107	.067	.089
15	16	.134	.045	.045	.107	.134	.045	.107	.107	.089	.089	.089	.089	.089	.067	.107	.107	.067	.089
16	17	.133	.044	.044	.107	.133	.044	.107	.107	.089	.089	.089	.089	.089	.067	.107	.107	.067	.089
17	18	.133	.044	.044	.107	.133	.044	.107	.107	.089	.089	.089	.089	.089	.067	.107	.107	.067	.089
18	19	.132	.044	.044	.106	.132	.044	.106	.106	.088	.088	.088	.088	.088	.066	.106	.106	.066	.088
19	20	.132	.044	.044	.106	.132	.044	.106	.106	.088	.088	.088	.088	.088	.066	.106	.106	.066	.088
20	21	.131	.044	.044	.105	.131	.044	.105	.105	.087	.087	.087	.087	.087	.066	.105	.105	.066	.087
21	22	.131	.044	.044	.105	.131	.044	.105	.105	.087	.087	.087	.087	.087	.066	.105	.105	.066	.087
22	23	.130	.043	.043	.104	.130	.043	.104	.104	.087	.087	.087	.087	.087	.065	.104	.104	.065	.087
23	24	.130	.043	.043	.104	.130	.043	.104	.104	.087	.087	.087	.087	.087	.065	.104	.104	.065	.087
24	25	.130	.043	.043	.104	.130	.043	.104	.104	.087	.087	.087	.087	.087	.065	.104	.104	.065	.087

The above table is based upon the specifications of the American Concrete Institute, for simple beams and continuous beams of approximately equal spans.

CASE 1. For fully restrained beams of 3 or more spans is based on the assumption that $I \div l$ is less than twice the sum of the values of $I \div h$ for exterior column above and below the beam. CASE 2 applies when $I \div l$ is equal to or exceeds twice the sum of the values of $I \div h$ for exterior column above and below. "I" is the moment of inertia of the section; "l" and "h" are span length and column height respectively.

Continuous beams with substantially unequal spans must be designed for true moment.

The above table is particularly useful in designing beams or girders into which concrete joist frame. Very often such beams or girders are designed on the assumption that the load is uniform throughout the span length, when in reality such is not the case.

Example: It is desired to find the bending moment of a beam of 20′-0″ span, carrying a floor load of 150 #/□′ from 18′-0″ of joist, spaced 24″ centers. The weight of the beam is assumed as 500# per lineal foot. A moment factor of $Wl \div 12$ is to be used.

The ordinary procedure is to figure the load per lin. ft. as uniform, which would be 18 × 150 = 2,700# from the joist, plus dead load of beam of 500#, or a total of 2,700 +500 = 3,200#. The moment would then be $M = \frac{3,200 \times 20^2}{12} = 106,500$ ft. lbs.

Since the joist are spaced 24″ or 2′-0″ on centers, the beam will actually carry a series of equally spaced concentrated loads. Inspection shows that there will be ten equal spaces, or nine equal concentrated loads. By referring to the proper column of $\frac{Wl}{12}$ in the table, for nine loads the co-efficient is 0.093. The actual moment is then 0.093 × 3,200 × 20² = 119,000 ft. lbs.

Find Ratio $\frac{b}{l}$ for Position of Load. Moment for that Position Will Then Be $P \times b \times C_M$

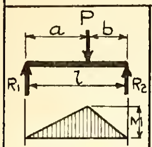
MOMENT COEFFICIENTS FOR BEAMS

WITH CONCENTRATED LOAD

GIVING "C_M" VALUES FOR MOMENT IN BOTH FOOT AND INCH LBS.

FOR ANY POSITION OF LOAD

$C_M = \frac{M}{Pb}$



$R_1=\frac{Pb}{l}$ $R_2=\frac{Pa}{l}$

$M=\frac{Pab}{l}$

SIMPLE BEAM

CONC. LOAD

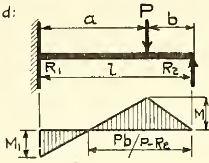
For Concentrated Load:

$R_1=\frac{P}{2l^3}(3bl^2-b^3)$

$R_2=\frac{P}{2l^3}(2l^3-3bl^2+b^3)$

For Uniform Load:

$R_1=\frac{5}{8}Wl;\ R_2=\frac{3}{8}Wl.$



For Concentrated Load:

$M=\frac{Pb}{2l^3}(2l^3-3bl^2+b^3)$

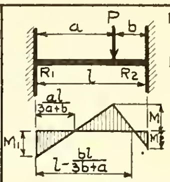
$M_1=\frac{P}{2l^2}(bl^2-b^3)$

For Uniform Load:

$M=\frac{9}{128}Wl;\ M_1=-\frac{1}{8}Wl.$

ONE END FIXED—ONE SUPPORTED

CONCENTRATED LOAD



For Concentrated Load:

$R_1=P\left(\frac{b^2(3a+b)}{l^3}\right)$

$R_2=P\left(\frac{a^2(3b+a)}{l^3}\right)$

$M=R_1a-P\frac{ab^2}{l^2}$

$M_1=P\frac{ab^2}{l^2};\ M_2=P\frac{a^2b}{l^2}$

For Uniform Load:

$R_1=R_2=W\div 2$

$M=\frac{Wl}{24};\ \ M_1=\frac{Wl}{12}$

BOTH ENDS FIXED

CONCENTRATED LOAD

Simple Beam — Conc. Load

$\frac{b}{l}$	C_M for M		Reactions	
	Ft. Lbs.	In. Lbs.	R_1	R_2
.01	.99	11.88	.01	.99
.02	.98	11.76	.02	.98
.03	.97	11.64	.03	.97
.04	.96	11.52	.04	.96
.05	.95	11.40	.05	.95
.06	.94	11.28	.06	.94
.07	.93	11.16	.07	.93
.08	.92	11.04	.08	.92
.09	.91	10.92	.09	.91
.10	.90	10.80	.10	.90
.11	.89	10.68	.11	.89
.12	.88	10.56	.12	.88
.13	.87	10.44	.13	.87
.14	.86	10.32	.14	.86
.15	.85	10.20	.15	.85
.16	.84	10.08	.16	.84
.17	.83	9.96	.17	.83
.18	.82	9.84	.18	.82
.19	.81	9.72	.19	.81
.20	.80	9.60	.20	.80
.21	.79	9.48	.21	.79
.22	.78	9.36	.22	.78
.23	.77	9.24	.23	.77
.24	.76	9.12	.24	.76
.25	.75	9.00	.25	.75
.26	.74	8.88	.26	.74
.27	.73	8.76	.27	.73
.28	.72	8.64	.28	.72
.29	.71	8.52	.29	.71
.30	.70	8.40	.30	.70
.31	.69	8.28	.31	.69
.32	.68	8.16	.32	.68
.33	.67	8.04	.33	.67
.34	.66	7.92	.34	.66
.35	.65	7.80	.35	.65
.36	.64	7.68	.36	.64
.37	.63	7.56	.37	.63
.38	.62	7.44	.38	.62
.39	.61	7.32	.39	.61
.40	.60	7.20	.40	.60
.41	.59	7.08	.41	.59
.42	.58	6.96	.42	.58
.43	.57	6.84	.43	.57
.44	.56	6.72	.44	.56
.45	.55	6.60	.45	.55
.46	.54	6.48	.46	.54
.47	.53	6.36	.47	.53
.48	.52	6.24	.48	.52
.49	.51	6.12	.49	.51
.50	.50	6.00	.50	.50

One End Fixed — One Supported, Concentrated Load

$\frac{b}{l}$	C_M for M		C_M for M_1		Reactions	
	Ft. Lbs.	In. Lbs.	Ft. Lbs.	In. Lbs.	R_1	R_2
.01	.985	11.820	.500	6.000	.0150	.9850
.02	.970	11.640	.499	5.998	.0200	.9800
.03	.955	11.460	.499	5.995	.0450	.9550
.04	.940	11.280	.499	5.990	.0600	.9400
.05	.925	11.101	.498	5.986	.0750	.9250
.06	.910	10.921	.498	5.978	.0900	.9100
.07	.895	10.742	.498	5.971	.1048	.8952
.08	.880	10.564	.497	5.962	.1197	.8803
.09	.865	10.385	.496	5.952	.1346	.8654
.10	.851	10.206	.495	5.940	.1495	.8505
.11	.836	10.028	.494	5.928	.1643	.8357
.12	.821	9.851	.493	5.914	.1791	.8209
.13	.806	9.673	.492	5.899	.1939	.8061
.14	.791	9.497	.490	5.882	.2086	.7914
.15	.777	9.320	.489	5.866	.2233	.7767
.16	.762	9.145	.487	5.846	.2379	.7621
.17	.748	8.970	.486	5.827	.2525	.7475
.18	.733	8.795	.484	5.806	.2671	.7329
.19	.718	8.621	.482	5.784	.2816	.7184
.20	.704	8.448	.480	5.760	.2960	.7040
.21	.690	8.275	.478	5.735	.3104	.6896
.22	.675	8.104	.476	5.710	.3247	.6753
.23	.661	7.933	.474	5.683	.3389	.6611
.24	.647	7.763	.471	5.654	.3531	.6469
.25	.633	7.594	.469	5.626	.3672	.6328
.26	.619	7.426	.466	5.594	.3812	.6188
.27	.605	7.258	.464	5.563	.3952	.6048
.28	.591	7.092	.461	5.530	.4090	.5910
.29	.577	6.926	.458	5.496	.4228	.5772
.30	.564	6.762	.455	5.460	.4365	.5635
.31	.550	6.599	.452	5.424	.4501	.5499
.32	.536	6.437	.449	5.386	.4636	.5364
.33	.523	6.276	.446	5.347	.4770	.5230
.34	.510	6.116	.442	5.306	.4903	.5097
.35	.496	5.957	.439	5.266	.5036	.4964
.36	.483	5.800	.435	5.222	.5167	.4833
.37	.470	5.644	.432	5.179	.5297	.4703
.38	.457	5.489	.428	5.134	.5426	.4574
.39	.445	5.336	.424	5.088	.5553	.4447
.40	.432	5.184	.420	5.040	.5680	.4320
.41	.420	5.034	.416	4.991	.5805	.4195
.42	.407	4.884	.412	4.942	.5929	.4071
.43	.395	4.738	.408	4.891	.6052	.3948
.44	.383	4.591	.403	4.838	.6174	.3826
.45	.371	4.447	.399	4.786	.6294	.3706
.46	.359	4.304	.394	4.730	.6413	.3587
.47	.347	4.163	.390	4.675	.6531	.3469
.48	.335	4.024	.385	4.618	.6647	.3353
.49	.324	3.886	.378	4.536	.6762	.3238
.50	.313	3.750	.375	4.500	.6875	.3125
.51	.301	3.616	.370	4.440	.6987	.3013
.52	.290	3.484	.365	4.378	.7097	.2903
.53	.279	3.353	.360	4.315	.7206	.2794
.54	.269	3.224	.354	4.250	.7313	.2687
.55	.258	3.098	.349	4.186	.7418	.2582
.56	.248	2.974	.343	4.118	.7522	.2478
.57	.238	2.851	.338	4.051	.7624	.2376
.58	.228	2.731	.332	3.982	.7724	.2276
.59	.218	2.612	.326	3.912	.7823	.2177
.60	208	2.496	.320	3.840	.7970	.2030
.61	.199	2.382	.314	3.767	.8015	.1985
.62	.189	2.270	.308	3.694	.8108	.1892
.63	.180	2.160	.302	3.619	.8199	.1801
.64	.171	2.053	.295	3.542	.8289	.1711
.65	.162	1.948	.289	3.466	.8377	.1623
.66	.154	1.844	.282	3.386	.8463	.1537
.67	.145	1.745	.276	3.307	.8546	.1454
.68	.137	1.646	.269	3.226	.8628	.1372
.69	.129	1.552	.262	3.144	.8707	.1293
.70	.122	1.458	.255	3.060	.8785	.1215
.71	.114	1.368	.248	2.976	.8860	.1140
.72	.107	1.279	.241	2.890	.8934	.1066
.73	.100	1.194	.234	2.803	.9005	.0995
.74	.093	1.111	.226	2.714	.9074	.0926
.75	.086	1.031	.219	2.626	.9141	.0859
.76	.079	.954	.211	2.534	.9205	.0795
.77	.073	.873	.204	2.443	.9267	.0733
.78	.067	.807	.196	2.350	.9327	.0673
.79	.062	.738	.188	2.256	.9385	.0615
.80	.056	.672	.180	2.160	.9440	.0560
.81	.051	.609	.172	2.063	.9493	.0507
.82	.046	.548	.164	1.966	.9543	.0457
.83	.041	.491	.156	1.867	.9591	.0409
.84	.036	.436	.147	1.766	.9636	.0364
.85	.032	.385	.139	1.666	.9679	.0321
.86	.028	.336	.130	1.562	.9719	.0281
.87	.024	.291	.122	1.459	.9757	.0243
.88	.021	.249	.113	1.354	.9793	.0207
.89	.017	.210	.104	1.248	.9825	.0175
.90	.015	.174	.095	1.140	.9855	.0145
.91	.0118	.1415	.0860	1.031	.9882	.0118
.92	.0093	.1121	.0768	.9216	.9907	.0093
.93	.0072	.0861	.0676	.8106	.9928	.0072
.94	.0053	.0635	.0582	.6984	.9947	.0053
.95	.0037	.0442	.0488	.5850	.9963	.0037
.96	.0024	.0284	.0392	.4704	.9976	.0024
.97	.0013	.0160	.0296	.3546	.9987	.0013
.98	.0006	.0072	.0198	.2376	.9994	.0006
.99	.00015	.0018	.0100	.1194	.9998	.0002

Both Ends Fixed — Concentrated Load

$\frac{b}{l}$	C_M for M_1		C_M for M_2		C_M for M		Reactions	
	Ft. Lbs.	In. Lbs.	Ft. Lbs.	In. Lbs.	Ft. Lbs.	In. Lbs.	R_1	R_2
.01	.0099	.1188	.980	11.761	.020	.235	.0003	.9997
.02	.0196	.2352	.960	11.525	.038	.461	0012	.9988
.03	.0291	.3492	.941	11.291	.057	.678	.0026	.9974
.04	.0384	.4608	.922	11.059	.074	.884	.0047	.9953
.05	.0475	.5700	.903	10.830	.090	1.081	.0073	.9927
.06	.0564	.6768	.884	10.603	.106	1.272	.0104	.9896
.07	.0651	.7812	.865	10.379	.121	1.453	.0140	.9860
.08	.0736	.8832	.846	10.157	.135	1.625	.0182	.9818
.09	.0819	.9828	.828	9.937	.149	1.789	.0228	.9772
.10	.0900	1.080	.810	9.720	.162	1.944	.0280	.9720
.11	.0979	1.175	.792	9.505	.174	2.092	.0336	.9664
.12	.1056	1.267	.774	9.293	.186	2.231	.0397	.9603
.13	.1131	1.357	.757	9.083	.197	2.362	.0463	.9537
.14	.1204	1.445	.740	8.875	.207	2.485	.0533	.9467
.15	.1275	1.530	.723	8.670	.217	2.602	.0608	.9392
.16	.1344	1.613	.706	8.467	.226	2.710	.0686	.9314
.17	.1411	1.693	.689	8.267	.234	2.810	.0769	.9231
.18	.1476	1.771	.672	8.069	.242	2.905	.0855	.9145
.19	.1539	1.847	.656	7.873	.249	2.992	.0946	.9054
.20	.1600	1.920	.640	7.680	.256	3.072	.1040	.8960
.21	.1659	1.991	.624	7.489	.262	3.145	.1138	.8862
.22	.1716	2.059	.608	7.301	.268	3.212	.1239	.8761
.23	.1771	2.125	.593	7.115	.273	3.272	.1344	.8656
.24	.1824	2.189	.578	6.931	.277	3.328	.1452	.8548
.25	.1875	2.250	.563	6.750	.281	3.376	.1563	.8437
.26	.1924	2.309	.548	6.571	.285	3.418	.1676	.8324
.27	.1971	2.365	.533	6.395	.288	3.454	.1793	.8207
.28	.2016	2.419	.518	6.221	.290	3.484	.1913	.8087
.29	.2059	2.471	.504	6.049	.292	3.509	.2035	.7965
.30	.2100	2.520	.490	5.880	.294	3.528	.2160	.7840
.31	.2139	2.567	.476	5.713	.295	3.542	.2287	.7713
.32	.2176	2.611	.462	5.549	.296	3.551	.2417	.7583
.33	.2211	2.653	.449	5.387	.296	3.556	.2548	.7452
.34	.2244	2.693	.436	5.227	.296	3.554	.2682	.7318
.35	.2275	2.730	.423	5.070	.296	3.550	.2818	.7182
.36	.2304	2.765	.410	4.915	.295	3.539	.2955	.7045
.37	.2331	2.797	.397	4.763	.294	3.524	.3094	.6906
.38	.2356	2.827	.384	4.613	.292	3.505	.3235	.6765
.39	.2379	2.855	.372	4.465	.290	3.482	.3377	.6623
.40	.2400	2.880	.360	4.320	.288	3.456	.3520	.6480
.41	.2419	2.903	.348	4.177	.285	3.425	.3665	.6335
.42	.2436	2.923	.336	4.037	.283	3.391	.3810	.6190
.43	.2451	2.941	.325	3.899	.279	3.353	.3957	.6043
.44	.2464	2.957	.314	3.763	.276	3.312	.4104	.5896
.45	.2475	2.970	.303	3.630	.272	3.268	.4253	.5747
.46	.2484	2.981	.292	3.499	.268	3.220	.4401	.5599
.47	.2491	2.989	.281	3.371	.264	3.169	.4551	.5449
.48	.2496	2.995	.270	3.245	.260	3.115	.4700	.5300
.49	.2499	2.999	.260	3.121	.255	3.059	.4850	.5150
.50	.2500	3.000	.250	3.000	.250	3.000	.5000	.5000

MOMENTS OF BEAMS FOR VARIOUS SPANS

UNIFORMLY LOADED

w = Total Load Per Lineal Foot, in Lbs.

$$\text{Moment} = \frac{wl^2}{12}$$

W = LOAD PER FT.	MOMENTS IN KIP FOOT POUNDS FOR SPANS IN FEET AS SHOWN																					W = LOAD PER FT.
	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1100	9.0	11.0	13.0	15.5	18.0	20.5	23.5	26.5	29.5	33.0	36.5	40.5	44.5	48.5	53.0	57.5	62.0	67.0	72.0	77.0	82.5	1100
1200	10.0	12.0	14.0	17.0	19.5	22.5	25.5	29.0	32.5	36.0	40.0	44.0	48.5	53.0	57.5	62.5	67.5	73.0	78.5	84.0	90.0	1200
1300	11.0	13.0	15.5	18.5	21.0	24.5	27.5	31.5	35.0	39.0	43.5	48.0	52.5	57.5	62.5	68.0	73.5	79.0	85.0	91.0	97.5	1300
1400	11.5	14.0	17.0	19.5	23.0	26.5	30.0	33.5	38.0	42.0	46.5	51.5	56.5	61.5	67.0	73.0	79.0	85.0	91.5	98.0	105.0	1400
1500	12.5	15.0	18.0	21.0	24.5	28.0	32.0	36.0	40.5	45.0	50.0	55.0	60.5	66.0	72.0	78.0	84.5	91.0	98.0	105.0	112.5	1500
1600	13.0	16.0	19.0	22.5	26.0	30.0	34.0	38.5	43.0	48.0	53.5	59.0	64.5	70.5	77.0	83.5	90.0	97.0	104.5	112.0	120.0	1600
1700	14.0	17.0	20.5	24.0	28.0	32.0	36.5	41.0	46.0	51.0	56.5	62.5	68.5	75.0	81.5	88.5	96.0	103.0	110.0	119.0	127.5	1700
1800	15.0	18.0	21.5	25.5	29.5	34.0	38.5	43.5	48.5	54.0	60.0	66.0	72.5	79.5	86.5	94.0	101.5	109.5	117.5	126.0	135.0	1800
1900	16.0	19.0	23.0	27.0	31.0	35.5	40.5	46.0	51.5	57.0	63.5	70.0	76.5	84.0	91.0	99.0	107.0	115.5	124.0	133.0	142.5	1900
2000	16.5	20.0	24.0	28.0	32.5	37.5	42.5	48.0	54.0	60.0	66.5	73.5	80.5	88.0	96.0	104.0	112.5	121.5	130.5	140.0	150.0	2000
2100	17.5	21.0	25.0	29.5	34.5	39.5	45.0	50.5	56.5	63.0	70.0	77.0	84.5	92.5	101.0	109.5	118.0	127.5	137.0	147.0	157.5	2100
2200	18.3	22.0	26.5	31.0	36.0	41.5	47.0	53.0	59.5	66.0	73.5	81.0	88.5	97.0	105.5	114.5	124.0	133.5	143.5	154.0	165.0	2200
2300	19.0	23.0	27.5	32.5	37.5	43.0	49.0	55.5	62.0	69.0	76.5	84.5	93.0	101.5	110.5	120.0	129.5	139.5	150.0	161.0	172.5	2300
2400	20.0	24.0	29.0	34.0	39.0	45.0	51.0	58.0	65.0	72.0	80.0	88.0	97.0	106.0	115.0	125.0	135.0	145.5	156.5	168.0	180.0	2400
2500	21.0	25.0	30.0	35.0	41.0	47.0	53.5	60.0	67.5	75.0	83.5	92.0	101.0	110.0	120.0	130.0	141.0	152.0	163.0	175.0	187.5	2500
2600	21.5	26.0	31.0	36.5	42.5	49.0	55.5	62.5	70.0	78.0	86.5	95.5	105.0	114.5	125.0	135.0	146.5	158.0	169.5	182.0	195.0	2600
2700	22.5	27.0	32.5	38.0	44.0	50.5	57.5	65.0	73.0	81.0	90.0	99.0	109.0	119.0	130.0	140.5	152.0	164.0	176.0	189.0	202.5	2700
2800	23.5	28.0	33.5	39.5	45.5	52.5	60.0	67.5	75.5	84.0	93.5	103.0	113.0	123.5	134.5	146.0	157.5	170.0	182.5	196.0	210.0	2800
2900	24.0	29.0	35.0	41.0	47.5	54.5	62.0	70.0	78.5	87.0	96.5	106.5	117.0	128.0	139.5	151.0	163.5	176.0	189.0	203.0	217.5	2900
3000	25.0	30.0	36.0	42.0	49.0	56.5	64.0	72.5	81.0	90.0	100.0	110.0	121.0	132.0	144.0	156.0	169.0	182.0	196.0	210.0	225.0	3000
3100	26.0	31.5	37.0	43.5	50.5	58.0	66.0	74.5	84.0	93.0	103.5	114.0	125.0	136.5	149.0	161.0	174.5	188.0	202.5	217.0	232.5	3100
3200	26.5	32.5	38.5	45.0	52.5	60.0	68.5	77.0	86.5	96.0	106.5	117.5	129.0	141.0	153.5	166.5	180.0	194.0	209.0	224.0	240.0	3200
3300	27.5	33.5	39.5	46.5	54.0	62.0	70.5	79.5	89.0	99.0	110.0	121.0	133.0	145.5	158.5	172.0	186.0	200.5	215.5	231.0	247.5	3300
3400	28.5	34.5	41.0	48.0	55.5	64.0	72.5	82.0	92.0	102.0	113.5	125.0	137.0	150.0	163.5	177.0	191.5	206.5	222.0	238.0	255.0	3400
3500	29.0	35.5	42.0	49.5	57.0	65.5	74.5	84.5	94.5	105.0	116.5	128.5	141.0	154.0	168.0	182.0	197.0	212.5	228.5	245.0	262.5	3500
3600	30.0	36.5	43.0	50.5	59.0	67.5	77.0	86.5	97.5	108.0	120.0	132.0	145.0	158.5	173.0	187.5	203.0	218.5	235.0	252.0	270.0	3600
3700	31.0	37.5	44.5	52.0	60.5	69.5	79.0	89.0	100.0	111.0	123.5	136.0	149.0	163.0	177.5	192.5	208.0	224.5	241.5	259.0	277.5	3700
3800	31.5	38.5	46.5	53.5	62.0	71.5	81.0	91.5	102.5	114.5	126.5	139.5	153.0	167.5	182.5	198.0	214.0	230.5	248.0	266.0	285.0	3800
3900	32.5	39.5	47.0	55.0	63.5	73.0	83.5	94.0	105.0	117.5	130.0	143.0	157.0	172.0	187.5	203.0	219.5	237.0	254.5	273.0	292.5	3900
4000	33.5	40.5	48.0	56.5	65.5	75.0	85.5	96.5	108.0	120.5	133.5	147.0	161.0	176.0	192.0	208.5	225.0	243.0	261.0	280.0	300.0	4000

$$\text{Moment} = \frac{wl^2}{10}$$

W = LOAD PER FT.	MOMENTS IN KIP FOOT POUNDS FOR SPANS IN FEET AS SHOWN																					W = LOAD PER FT.
	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1100	11.0	13.5	16.0	18.5	21.5	25.0	28.0	32.0	35.5	39.5	44.0	48.5	53.5	58.0	63.5	69.0	74.5	80.0	86.0	92.5	99.0	1100
1200	12.0	14.5	17.5	20.5	23.5	27.0	30.5	34.5	39.0	43.5	48.0	53.0	58.0	63.5	69.0	75.0	81.0	87.5	94.0	101.0	108.0	1200
1300	13.0	15.5	18.5	22.0	25.5	29.0	33.5	37.5	42.0	47.0	52.0	57.5	63.0	69.0	75.0	81.0	88.0	95.0	102.0	109.0	117.0	1300
1400	14.0	17.0	20.0	23.5	27.5	31.5	36.0	40.5	45.5	50.5	56.0	62.0	68.0	74.0	80.5	87.5	94.5	102.0	110.0	117.5	126.0	1400
1500	15.0	18.0	21.5	25.5	29.5	34.0	38.5	43.5	48.5	54.0	60.0	66.0	72.5	79.5	86.5	94.0	101.5	109.5	117.5	126.0	135.0	1500
1600	16.0	19.5	23.0	27.0	31.5	36.0	41.0	46.0	52.0	58.0	64.0	70.5	77.5	84.5	92.0	100.0	108.0	116.5	125.5	134.5	144.0	1600
1700	17.0	20.5	24.5	28.5	33.5	38.0	43.5	49.0	55.0	61.5	68.0	75.0	82.5	90.0	98.0	106.5	115.0	124.0	133.0	143.0	153.0	1700
1800	18.0	22.0	26.0	30.5	35.5	40.5	46.0	52.0	58.5	65.0	72.0	79.5	87.0	95.0	103.5	112.5	121.5	131.0	141.0	151.5	162.0	1800
1900	19.0	23.0	27.5	32.0	37.0	43.0	48.5	55.0	61.5	68.5	76.0	84.0	92.0	100.5	109.5	119.0	128.5	138.5	149.0	159.5	171.0	1900
2000	20.0	24.0	29.0	34.0	39.0	45.0	51.0	58.0	65.0	72.0	80.0	88.0	97.0	105.5	115.0	125.0	135.0	146.0	157.0	168.0	180.0	2000
2100	21.0	25.5	30.0	35.5	41.0	47.5	53.5	60.5	68.0	76.0	84.0	92.5	101.5	111.0	121.0	131.5	142.0	153.0	164.5	176.5	189.0	2100
2200	22.0	26.5	31.5	37.0	43.0	49.5	56.5	63.5	71.5	79.5	88.0	97.0	106.5	116.5	126.5	137.5	148.5	160.5	172.5	185.0	198.0	2200
2300	23.0	28.0	33.0	39.0	45.0	52.0	59.0	66.5	74.5	83.0	92.0	101.5	111.0	121.5	132.5	144.0	155.5	168.0	180.5	193.5	207.0	2300
2400	24.0	29.0	34.5	40.5	47.0	54.0	61.5	69.5	78.0	86.5	96.0	106.0	116.0	127.0	138.0	150.0	162.0	175.0	188.0	202.0	216.0	2400
2500	25.0	30.0	36.0	42.5	49.0	56.5	64.0	72.5	81.0	90.0	100.0	110.0	121.0	132.0	144.0	156.5	169.0	182.0	196.0	210.0	225.0	2500
2600	26.0	31.5	37.5	44.0	51.0	58.5	66.5	75.0	84.0	94.0	104.0	115.0	126.0	137.5	150.0	162.5	175.5	189.5	204.0	219.0	234.0	2600
2700	27.0	32.5	39.0	45.5	53.0	61.0	69.0	78.0	87.5	97.5	108.0	119.0	130.5	143.0	155.5	169.0	182.5	197.0	212.0	227.0	243.0	2700
2800	28.0	34.0	40.5	47.5	55.0	63.0	71.5	81.0	91.0	101.0	112.0	123.5	135.5	148.0	161.5	175.0	189.5	204.0	220.0	235.0	252.0	2800
2900	29.0	35.0	42.0	49.0	57.0	65.5	74.0	84.0	94.0	104.5	116.0	128.0	140.5	153.5	167.0	181.5	196.0	211.5	227.5	244.0	261.0	2900
3000	30.0	36.5	43.0	51.0	59.0	67.5	77.0	87.0	97.0	108.0	120.0	132.5	145.0	158.5	173.0	187.5	203.0	219.0	235.0	252.0	270.0	3000
3100	31.0	37.5	44.5	52.5	61.0	70.0	79.5	89.5	100.5	112.0	124.0	137.0	150.0	164.0	178.5	194.0	209.5	226.0	243.0	261.0	279.0	3100
3200	32.0	38.7	46.0	54.0	63.0	72.0	82.0	92.5	103.5	115.5	128.0	141.0	155.0	169.0	184.5	200.0	216.0	233.5	251.0	269.0	288.0	3200
3300	33.0	40.0	47.5	56.0	65.0	74.5	84.5	95.5	107.0	119.0	132.0	145.5	159.5	174.5	190.0	206.5	223.0	241.0	259.0	278.0	297.0	3300
3400	34.0	41.0	49.0	57.5	66.5	76.5	87.0	98.5	110.0	122.5	136.0	150.0	164.5	180.0	196.0	212.5	230.0	248.0	267.0	286.0	306.0	3400
3500	35.0	42.5	50.5	59.0	68.5	79.0	89.5	101.0	113.5	126.0	140.0	154.5	169.5	185.0	202.0	219.0	236.5	255.0	274.5	294.0	315.0	3500
3600	36.0	43.5	52.0	61.0	70.5	81.0	92.0	104.0	116.5	130.0	144.0	159.0	174.0	190.5	207.5	225.0	243.5	262.5	282.0	303.0	334.0	3600
3700	37.0	44.5	53.5	62.5	72.5	83.5	94.5	107.0	120.0	133.5	148.0	163.0	179.0	195.5	213.5	231.5	250.0	270.0	290.0	311.0	333.0	3700
3800	38.0	46.0	54.5	64.0	74.5	85.5	97.5	109.5	123.0	137.0	152.0	167.5	184.0	201.0	219.0	237.5	257.0	277.0	298.0	320.0	342.0	3800
3900	39.0	47.0	56.0	66.0	76.5	88.0	100.0	112.5	126.5	140.5	156.0	172.0	189.0	206.5	225.0	244.0	264.0	284.5	306.0	328.0	351.0	3900
4000	40.0	48.5	57.5	67.6	78.5	90.0	102.5	115.5	129.5	144.5	160.0	176.5	193.5	211.5	230.5	250.0	270.0	292.0	314.0	337.0	360.0	4000

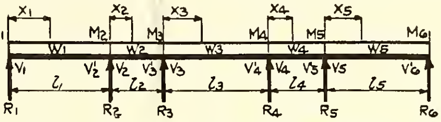
CONTINUOUS BEAMS

The moment factors in common use for the design of continuous beams, while generaly safe enough, do not always apply. For instance, with unequal spans, a portion of which, only, are loaded, investigation of the critical moments and shears should be made, using the Theorem of Three Moments.

It is assumed that the moment of inertia is constant and that the supports are perfectly rigid. For any variation in this assumption, consult a recognized authority.

Knife edge supports are assumed, whereas this condition is seldom if ever realized. Induced moments in columns are disregarded. For this reason any important problem in which there is a degree of joint fixity should be investigated as a Rigid Frame.

Theorem—Uniform Load.



Assume a beam of any number of spans, with uniform load. The basic equation, for the first two spans, and thus considering moments M_1, M_2 and M_3, at the supports, is:

$$M_1l_1 + 2M_2\,(l_1 + l_2) + M_3l_2 = -\frac{w_1l_1^3}{4} - \frac{w_2l_2^3}{4}$$

For spans l_3 and l_4 the subscripts are changed and the formula becomes:

$$M_3l_3 + 2M_4\,(l_3 + l_4) + M_5l_4 = -\frac{w_3l_3^3}{4} - \frac{w_4l_4^3}{4}$$ and so on for additional spans.

Having found the moments at the supports, the shears and moments at any point are readily found.

$$V_1 = \frac{M_2 - M_1}{l_1} + \frac{w_1l_1}{2} \qquad V'_2 = V_1 - w_1l_1$$

$$V_2 = \frac{M_3 - M_2}{l_2} + \frac{w_2l_2}{2} \qquad V'_3 = V_2 - w_2l_2 \text{ and so on.}$$

The reaction at any support equals the shear on its right plus the shear left, with the sign reversed. The distance to point of zero shear in any span, if shear changes sign:

$$x_1 = \frac{V_1}{w_1} \text{ for span } l_1 \qquad x_2 = \frac{V_2}{w_2} \text{ for span } l_2$$

$$x_3 = \frac{V_3}{w_3} \text{ for span } l_3. \qquad x_4 = \frac{V_4}{w_4} \text{ for span } l_4 \text{ and so on.}$$

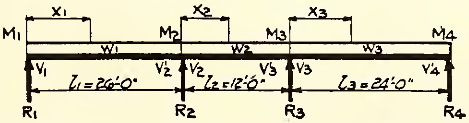
The bending moments in spans at points x_1, x_2, etc.

$$M = M_1 + V_1x_1 - \frac{w_1x_1^2}{2} \text{ for span } l_1. \qquad M = M_2 + V_2x_2 - \frac{w_2x_2^2}{2} \text{ for span } l_2\text{, and so on.}$$

Plus sign denotes maximum positive moment; minus sign denotes negative moment.

Example.

Continuous beam of 3 unequal spans, uniform load, framing into brick walls at end.



Total load 2,000# lin. ft.

End spans are simply supported; therefore M_1 and $M_4 = 0$. Moments M_2 and M_3 are desired.

$$M_2 = M_1l_1 + 2M_2\,(l_1 + l_2) + M_3l_2 = -\frac{w_1l_1^3}{4} - \frac{w_2l_2^3}{4}$$

$$M_3 = M_2l_2 + 2M_3\,(l_2 + l_3) + M_4l_3 = -\frac{w_2l_2^3}{4} - \frac{w_3l_3^3}{4}$$

Therefore

$$76M_2 + 12M_3 = -\frac{2{,}000 \times 26^3}{4} - \frac{2{,}000 \times 12^3}{4} = -9{,}654{,}000$$

$$12M_2 + 72M_3 = -\frac{2{,}000 \times 12^3}{4} - \frac{2{,}000 \times 24^3}{4} = -7{,}784{,}000$$

$$12M_3 = 9{,}654{,}000 - 76M_2 \qquad 72 \times 6.33 = 455.76 \qquad 443.76M_2 = +50{,}140{,}000$$

$$M_3 = 804{,}000 - 6.33M_2 \qquad -12.00 \qquad M_2 = -113{,}000$$

$$\overline{443.76} \qquad M_3 = -89{,}100$$

As a check: $(76 \times -113{,}000) + (12 \times -89{,}100) = -9{,}655{,}000$

$(12 \times -113{,}000) + (72 \times -89{,}100) = -7{,}775{,}000$

If slide rule is used, care should be taken to insure accuracy.

Shears.

$$V_1 = \frac{M_2 - M_1}{l_1} + \frac{w_1 l_1}{2} = \frac{-113{,}000 - 0}{26} + \frac{2{,}000 \times 26}{2} = 21{,}650$$

$$V'_2 = V_1 - w_1 l_1 = 21{,}650 - (2{,}000 \times 26) = -30{,}350$$

$$V_2 = \frac{M_3 - M_2}{l_2} + \frac{w_2 l_2}{2} = \frac{(89{,}100) - (-113{,}000)}{12} + \frac{2{,}000 \times 12}{2} = 13{,}990$$

$$V'_3 = V_2 - w_2 l_2 = 13{,}990 - (2{,}000 \times 12) = -10{,}010$$

$$V_3 = \frac{M_4 - M_3}{l_3} + \frac{w_3 l_3}{2} = \frac{(0) - (-89{,}100)}{24} + \frac{2{,}000 \times 24}{2} = 27{,}710$$

$$V'_4 = V_3 - w_3 l_3 = 27{,}710 - (2{,}000 \times 24) = -20{,}290$$

Reactions.

$R_1 = V_1 \qquad = \qquad = 21{,}650$
$R_2 = V_2 + V'_2 = 13{,}990 + 30{,}350 = 44{,}340$ Check: $62 \times 2{,}000 = 124{,}000$ Total load
$R_3 = V_3 + V'_3 = 27{,}710 + 10{,}010 = 37{,}720$
$R_4 = V'_4 \qquad = \qquad = 20{,}290$ Total 124,000

Point Zero Shear.

Distance x from left reaction:

$$x_1 = \frac{V_1}{w_1} = \frac{21{,}650}{2{,}000} = 10.83 \text{ ft.} \qquad x_3 = \frac{V_3}{w_3} = \frac{27{,}710}{2{,}000} = 13.86 \text{ ft.}$$

$$x_2 = \frac{V_2}{w_2} = \frac{13{,}990}{2{,}000} = 7.00 \text{ ft.}$$

Interior Moments.

$$M \text{ at } x_1 = M_1 + V_1 x_1 - \frac{w_1 x_1^2}{2} = 0 + 21{,}650 \times 10.83 - \frac{2{,}000 \times 10.83^2}{2} = +117{,}100 \text{ ft. lbs.}$$

$$M \text{ at } x_2 = M_2 + V_2 x_2 - \frac{w_2 x_2^2}{2} = (-113{,}000) + 13{,}990 \times 7.00 - \frac{2{,}000 \times 7.00^2}{2} = -33{,}930 \text{ ft. lbs.}$$

$$M \text{ at } x_3 = M_3 + V_3 x_3 - \frac{w_3 x_3^2}{2} = (-89{,}100) + 27{,}710 \times 13.86 - \frac{2{,}000 \times 13.86^2}{2} = +103{,}000 \text{ ft. lbs.}$$

Note that for this condition there is no positive moment in center span. If the two outer spans were loaded and the center span had no load, the maximum negative moment for the center span would be obtained. Where conditions require designing to meet the worst possible condition, investigation of beam with various spans loaded and unloaded should be made.

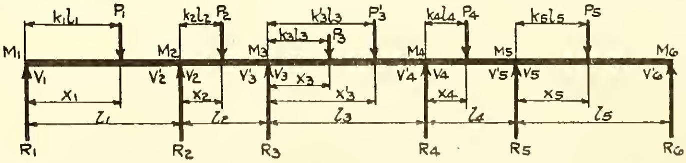
Beams Framing into Heavy Columns.

In the example given the beam was considered simply supported at the ends. If it frames into heavy columns the moment at the ends will not be zero, but will have a value depending upon the degree of fixity obtained, which may be considered as $\frac{wl^2}{20}$, $\frac{wl^2}{16}$ or $\frac{wl^2}{12}$, as may seem warranted. Computations for interior support moments will be similar to the example given, Moments M_1 and M_4 in the example being changed from zero to their proper values in the equation.

Continuous Beams With Concentrated Loads.

The formula for concentrated loads is:

$$M_1 l_1 + 2M_2 (l_1 + l_2) + M_3 l_2 = -\Sigma P_1 l_1^2 (k_1 - k_1^3) - \Sigma P_2 l_2^2 (2k_2 - 3k_2^2 + k_2^3) \text{ and so on.}$$



Once the moments at the supports are known, the moments and shears at any point are found as before.

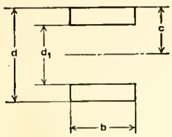
General.

Values of moment and shear co-efficients are given for various numbers of equal spans, equally loaded, with uniform loads, concentrated loads at center of span, and concentrated loads at third and quarter points of span. Examples are also given for continuous beams of two or more spans under various conditions of span loading.

PROPERTIES OF GEOMETRIC SECTIONS

EQUAL RECTANGLES

Axis of moments through center of gravity



$$A = b(d - d_1)$$

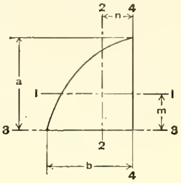
$$c = \frac{d}{2}$$

$$I = \frac{b(d^3 - d_1^3)}{12}$$

$$S = \frac{b(d^3 - d_1^3)}{6d}$$

$$r = \sqrt{\frac{d^3 - d_1^3}{12(d - d_1)}}$$

HALF PARABOLA



$$A = \frac{2}{3}ab$$

$$m = \frac{2}{5}a$$

$$n = \frac{3}{8}b$$

$$I_1 = \frac{8}{175}a^3b$$

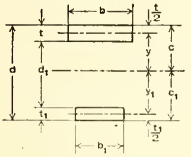
$$I_2 = \frac{19}{480}ab^3$$

$$I_3 = \frac{16}{105}a^3b$$

$$I_4 = \frac{2}{15}ab^3$$

UNEQUAL RECTANGLES

Axis of moments through center of gravity



$$A = bt + b_1t_1$$

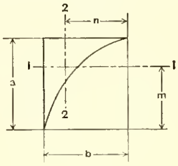
$$c = \frac{\frac{1}{2}bt^2 + b_1t_1(d - \frac{1}{2}t_1)}{A}$$

$$I = \frac{bt^3}{12} + bty^2 + \frac{b_1t_1^3}{12} + b_1t_1y_1^2$$

$$S = \frac{I}{c} \qquad S_1 = \frac{I}{c_1}$$

$$r = \sqrt{\frac{I}{A}}$$

COMPLEMENT OF HALF PARABOLA



$$A = \frac{1}{3}ab$$

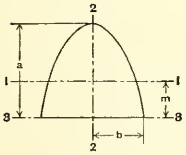
$$m = \frac{7}{10}a$$

$$n = \frac{3}{4}b$$

$$I_1 = \frac{37}{2100}a^3b$$

$$I_2 = \frac{1}{80}ab^3$$

PARABOLA



$$A = \frac{4}{3}ab$$

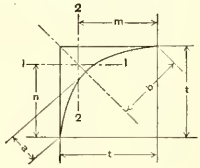
$$m = \frac{2}{5}a$$

$$I_1 = \frac{16}{175}a^3b$$

$$I_2 = \frac{4}{15}ab^3$$

$$I_3 = \frac{32}{105}a^3b$$

PARABOLIC FILLET IN RIGHT ANGLE



$$a = \frac{t}{2\sqrt{2}}$$

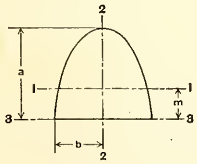
$$b = \frac{t}{\sqrt{2}}$$

$$A = \frac{1}{6}t^2$$

$$m = n = \frac{4}{5}t$$

$$I_1 = I_2 = \frac{11}{2100}t^4$$

* HALF ELLIPSE



$$A = \frac{1}{2}\pi ab$$

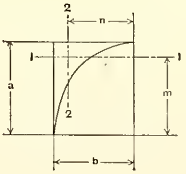
$$m = \frac{4a}{3\pi}$$

$$I_1 = a^3b\left(\frac{\pi}{8} - \frac{8}{9\pi}\right)$$

$$I_2 = \frac{1}{8}\pi ab^3$$

$$I_3 = \frac{1}{8}\pi a^3b$$

* ELLIPTIC COMPLEMENT



$$A = ab\left(1 - \frac{\pi}{4}\right)$$

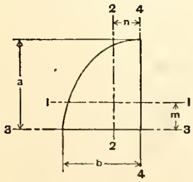
$$m = \frac{a}{6\left(1 - \frac{\pi}{4}\right)}$$

$$n = \frac{b}{6\left(1 - \frac{\pi}{4}\right)}$$

$$I_1 = a^3b\left(\frac{1}{3} - \frac{\pi}{16} - \frac{1}{36\left(1 - \frac{\pi}{4}\right)}\right)$$

$$I_2 = ab^3\left(\frac{1}{3} - \frac{\pi}{16} - \frac{1}{36\left(1 - \frac{\pi}{4}\right)}\right)$$

* QUARTER ELLIPSE



$$A = \frac{1}{4}\pi ab$$

$$m = \frac{4a}{3\pi}$$

$$n = \frac{4b}{3\pi}$$

$$I_1 = a^3b\left(\frac{\pi}{16} - \frac{4}{9\pi}\right)$$

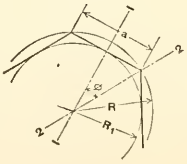
$$I_2 = ab^3\left(\frac{\pi}{16} - \frac{4}{9\pi}\right)$$

$$I_3 = \frac{1}{16}\pi a^3b$$

$$I_4 = \frac{1}{16}\pi ab^3$$

REGULAR POLYGON

Axis of moments through center



n = Number of sides

$$\phi = \frac{180^\circ}{n}$$

$$a = 2\sqrt{R^2 - R_1^2}$$

$$R = \frac{a}{2\sin\phi}$$

$$R_1 = \frac{a}{2\tan\phi}$$

$$A = \frac{1}{4}na^2\cot\phi = \frac{1}{2}nR^2\sin 2\phi = nR_1^2\tan\phi$$

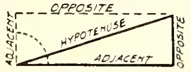
$$I_1 = I_2 = \frac{A(6R^2 - a^2)}{24} = \frac{A(12R_1^2 + a^2)}{48}$$

$$r_1 = r_2 = \sqrt{\frac{6R^2 - a^2}{24}} = \sqrt{\frac{12R_1^2 + a^2}{48}}$$

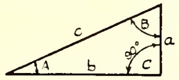
* To obtain properties of half circle, quarter circle and circular complement substitute a = b = R.

TRIGONOMETRIC FORMULAE, Etc.

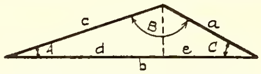
AMERICAN BRIDGE COMPANY


OPPOSITE
HYPOTENUSE
ADJACENT
ADJACENT
OPPOSITE

FUNCTIONS OF ANGLE	OPPOSITE	ADJACENT	HYP
$\sin = Op \div Hyp$	$Hyp \times \sin$		$Op \div \sin$
$\cos = Ad - Hyp$		$Hyp \times \cos$	$Ad \div \cos$
$\tan = Op - Ad$	$Ad \times \tan$	$Op - \tan$	
$\cot = Ad - Op$	$Ad - \cot$	$Op \times \cot$	
$\sec = Hy \div Ad$		$Hyp \div \sec$	$Ad \times \sec$
$\text{cosec} = Hy - Op$	$Hyp - \text{cosec}$		$Op \times \text{cosec}$

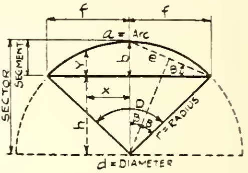


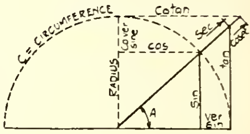
GIVEN	TO FIND	FORMULA
ab	A	$\tan = a - b$ $\quad \cot = b \div a$
	B	$\cot = a \div b$ $\quad \tan = b \div a$
ac	A	$\sin = a \div c$ $\quad \text{cosec} = c - a$
	B	$\cos = a - c$ $\quad \sec = c - a$
bc	A	$\sec = c \div b$ $\quad \cos = b - c$
	B	$\text{cosec} = c - b$ $\quad \sin = b - c$
Aa	b	$a \cot A$ $\quad a \div \tan A$
	c	$a \,\text{cosec}\, A$ $\quad a \div \sin A$
Ab	a	$b \tan A$ $\quad b - \cot A$
	c	$b \sec A$ $\quad b - \cos A$
Ac	a	$c \sin A$ $\quad c - \text{cosec}\, A$
	b	$c \cos A$ $\quad c \div \sec A$



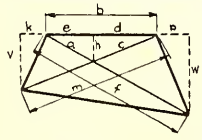
GIVEN	TO FIND	FORMULA
ABa	b	$a \sin B \div \sin A$
	c	$a \sin(A+B) \div \sin A$
ABb	a	$b \sin A \div \sin B$
	c	$b \sin(A+B) \div \sin B$
ABc	a	$c \sin A \div \sin(A+B)$
	b	$c \sin B \div \sin(A+B)$
ACa	b	$a \sin(A+C) \div \sin A$
	c	$a \sin C \div \sin A$
ACb	a	$b \sin A \div \sin(A+C)$
	c	$b \sin C \div \sin(A+C)$
ACc	a	$c \sin A \div \sin C$
	b	$c \sin(A+C) - \sin C$
BCa	b	$a \sin B \div \sin(B+C)$
	c	$a \sin C \div \sin(B+C)$
BCb	a	$b \sin(B+C) \div \sin B$
	c	$b \sin C \div \sin B$
BCc	a	$c \sin(B+C) \div \sin C$
	b	$c \sin B \div \sin C$
abc	s	$(a+b+c) - 2$
abcs	A	$\sin \tfrac{1}{2}A = \sqrt{(s-b)(s-c) - bc}$
		$\cos \tfrac{1}{2}A = \sqrt{s(s-a) - bc}$
		$\tan \tfrac{1}{2}A = \sqrt{(s-b)(s-c) \div s(s-a)}$
abcs	B	$\sin \tfrac{1}{2}B = \sqrt{(s-a)(s-c) \div ac}$
		$\cos \tfrac{1}{2}B = \sqrt{s(s-b) \div ac}$
		$\tan \tfrac{1}{2}B = \sqrt{(s-a)(s-c) - s(s-b)}$
abcs	C	$\sin \tfrac{1}{2}C = \sqrt{(s-a)(s-b) \div ab}$
		$\cos \tfrac{1}{2}C = \sqrt{s(s-c) - ab}$

GIVEN	TO FIND	FORMULA
abcs	C	$\tan \tfrac{1}{2}C = \sqrt{(s-a)(s-b) \div s(s-c)}$
abcs	d	$(b^2 + c^2 - a^2) \div 2b$
	e	$(a^2 + b^2 - c^2) \div 2b$
Aab	B	$\sin = b \sin A \div a$
Aac	C	$\sin = c \sin A \div a$
Bab	A	$\sin = a \sin B - b$
Bbc	C	$\sin = c \sin B \div b$
Cac	A	$\sin = a \sin C \div c$
Cbc	B	$\sin = b \sin C \div c$
Abc	$\tfrac{1}{2}(B+C)$	$90° - \tfrac{1}{2}A$
	$\tfrac{1}{2}(B-C)$	$\tan = [(b-c)\tan(90° - \tfrac{1}{2}A)] - (b+c)$
	B	$\tfrac{1}{2}(B+C) + \tfrac{1}{2}(B-C)$
	C	$\tfrac{1}{2}(B+C) - \tfrac{1}{2}(B-C)$
	a	$\sqrt{b^2 + c^2 - 2bc \cos A}$
Bac	$\tfrac{1}{2}(A+C)$	$90° - \tfrac{1}{2}B$
	$\tfrac{1}{2}(A-C)$	$\tan = [(a-c)\tan(90° - \tfrac{1}{2}B)] - (a+c)$
	A	$\tfrac{1}{2}(A+C) + \tfrac{1}{2}(A-C)$
	C	$\tfrac{1}{2}(A+C) - \tfrac{1}{2}(A-C)$
	b	$\sqrt{a^2 + c^2 - 2ac \cos B}$
Cab	$\tfrac{1}{2}(A+B)$	$90° - \tfrac{1}{2}C$
	$\tfrac{1}{2}(A-B)$	$\tan = [(a-b)\tan(90° - \tfrac{1}{2}C)] - (a+b)$
	A	$\tfrac{1}{2}(A+B) + \tfrac{1}{2}(A-B)$
	B	$\tfrac{1}{2}(A+B) - \tfrac{1}{2}(A-B)$
	c	$\sqrt{a^2 + b^2 - 2ab \cos C}$

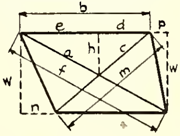

f
f
a = Arc
b
e
B
B
x
y
D
h
SECTOR
SEGMENT
r = RADIUS
d = DIAMETER


C = CIRCUMFERENCE
Cotan
sec
cos
Cosec
tan
Coversine
RADIUS
Sin
A
Ver Sin

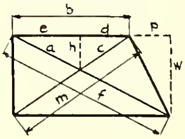
GIVEN	TO FIND	FORMULA
drB	b	$d \sin^2 B$
	f	$r \sin 2B$
	e	$d \sin B$
drb	Ang B	$\sin B = \sqrt{b \div d}$
	f	$\sqrt{b(d-b)}$
	e	$\sqrt{db}$
dre	Ang B	$\sin B = e \div d$
	b	$e^2 \div d$
	f	$e\sqrt{d^2 - e^2} \div d$
bB	r	$\tfrac{1}{2}b \div \sin^2 B$
eB	r	$\tfrac{1}{2}e - \sin B$
bf	Ang B	$\tan B = b \div f$
	r	$(f^2 + b^2) - 2b$
fe	Ang B	$\sin B = \sqrt{e^2 - f^2} \div e$
	r	$\tfrac{1}{2}e^2 \div \sqrt{e^2 - f^2}$
be	Ang B	$\sin B = b \div e$
	r	$\tfrac{1}{2}e^2 \div b$
rxy	Ang B	$\cos 2B = (\sqrt{r^2 - x^2} - y) \div r$
	b	$r + y - \sqrt{r^2 - x^2}$
brx	y	$b + \sqrt{r^2 - x^2} - r$
bry	x	$\sqrt{r^2 - (r+y-b)^2}$
bxy	r	$[x^2 + (b-y)^2] \div (2b - 2y)$
r	Circ.	$6.2832\, r$
rD	Arc a	$.0174533\, r D°$
	Arc a	$.0002909\, r D'$
	Arc a	$.00000485\, r D''$
r	Area	Circle $= 3.1416\, r^2$
d		" $= 0.7854\, d^2$
c		" $= 0.0796\, c^2$
ar		Sector $= 0.5\, ar$
arfh		Segment $= 0.5\, ar - fh$


b
k
e
d
p
v
a
h
c
w
m
f

GIVEN	TO FIND	FORMULA
bpw	f	$\sqrt{(b+p)^2 + w^2}$
bkv	m	$\sqrt{(b+k)^2 + v^2}$
bkp	d	$bw(b+k) - [v(b+p) + w(b+k)]$
vw	e	$bv(b+p) - [v(b+p) + w(b+k)]$
bfk pvw	a	$fbv - [v(b+p) + w(b+k)]$
bkm pvw	c	$bmw - [v(b+p) + w(b+k)]$
bkpvw	h	$bvw \div [v(b+p) + w(b+k)]$
afw	h	$aw - f$
cmv	h	$cv - m$

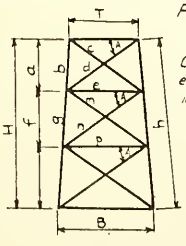

b
e
d
p
a
h
c
w
f
m
w
n

GIVEN	TO FIND	FORMULA
bpw	f	$\sqrt{(b+p)^2 + w^2}$
bnw	m	$\sqrt{(b-n)^2 + w^2}$
bnp	d	$b(b-n) \div (2b+p-n)$
	e	$b(b+p) \div (2b+p-n)$
bfnp	a	$bf \div (2b+p-n)$
bmnp	c	$bm \div (2b+p-n)$
bnpw	h	$bw - (2b+p-n)$
afw	h	$aw \div f$
cmw	h	$cw - m$


b
e
d
p
a
h
c
w
m
f

GIVEN	TO FIND	FORMULA
bpw	f	$\sqrt{(b+p)^2 + w^2}$
bw	m	$\sqrt{b^2 + w^2}$
bp	d	$b^2 \div (2b+p)$
	e	$b(b+p) \div (2b+p)$
bfp	a	$bf \div (2b+p)$
bmp	c	$bm \div (2b+p)$
bpw	h	$bw - (2b+p)$
afw	h	$aw \div f$
cmw	h	$cw \div m$

PARALLEL BRACING.


T
A
c
d
e
m
n
p
A
a
b
g
f
H
h
B

$K = (\text{Log } B - \text{Log } T) \div$ No panels

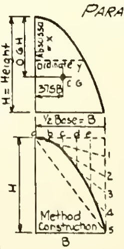
Constant "K" plus the log of any line equals the log of corresponding line in the next panel below.

$a = TH - (T+e+p) \qquad b = Th - (T+e+p)$

$c = \sqrt{(\tfrac{1}{2}T + \tfrac{1}{2}e)^2 + a^2} \qquad d = ce \div (T+e)$

$\text{Log } e = K + \text{Log } T$
" $f = K + \text{Log } a$
" $g = K + \text{Log } b$
" $m = K + \text{Log } c$
" $n = K + \text{Log } d$
" $p = K + \text{Log } e$

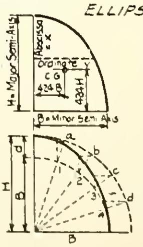
PARABOLA


H = Height
0.6 H
Abscissa = x
Ordinate y
CG
.375 B
½ Base = B
a
b
c
d
e
1
2
3
4
5
H
Method Construction
B

$P = \text{Perimeter} = B^2 - H$

$\text{Area} = \tfrac{2}{3}HB \qquad Y = \sqrt{xp} \qquad x = y^2 \div p$

ELLIPSE


H = Major Semi-Axis
Abscissa = x
Ordinate y
CG
.424 B
.424 H
B = Minor Semi Axis
a
b
c
d
1
2
3
4
d
H
B
B

$Y = (B \div H)\sqrt{H^2 - x^2} \qquad \text{Area} = .7854(2B \cdot 2H)$

$x = (H-B)\sqrt{B^2 - y^2} \qquad (x^2 \div H^2) + (y^2 \div B^2) = 1$

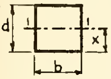
Radian = 57.2957795 deg
1 degree = 0.017453293 Radian
1 minute = 0.000290888 "
1 second = 0.000004848 "
Sphere: Volume = 4.1888 r^3
" = 0.5236 d^3
Surf area = 12.5664 r^2
" " = 3.1416 d^2

A = Area of Section
I = Moment of Inertia
S = Section Modulus
r = Radius of Gyration

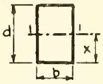
PROPERTIES OF SECTIONS

For rolled steel sections:

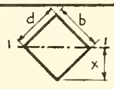
$$S = \frac{I}{x} \qquad r = \sqrt{\frac{I}{A}}$$



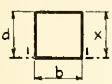
$$A = d^2; \quad x = \frac{d}{2}; \quad I_1 = \frac{d^4}{12}; \quad S_1 = \frac{d^3}{6}; \quad r_1 = \frac{d}{\sqrt{12}} = 0.288675d$$



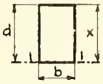
$$A = bd; \quad x = \frac{d}{2}; \quad I_1 = \frac{bd^3}{12}; \quad S_1 = \frac{bd^2}{6}; \quad r_1 = \frac{d}{\sqrt{12}} = 0.288675d$$



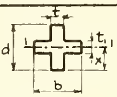
$$A = d^2; \quad x = \frac{d}{\sqrt{2}} = 0.707107d; \quad I_1 = \frac{d^4}{12}; \quad S_1 = \frac{d^3}{6\sqrt{2}} = 0.117851d^3; \quad r_1 = \frac{d}{\sqrt{12}} = 0.288675d$$



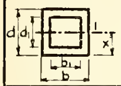
$$A = d^2; \quad x = d; \quad I_1 = \frac{d^4}{3}; \quad S_1 = \frac{d^3}{3}; \quad r_1 = \frac{d}{\sqrt{3}} = 0.57735d$$



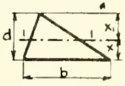
$$A = bd, \quad x = d; \quad I_1 = \frac{bd^3}{3}; \quad S_1 = \frac{bd^2}{3}; \quad r_1 = \frac{d}{\sqrt{3}} = 0.57735d$$



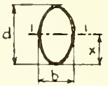
$$A = td + t_1(b-t); \quad x = \frac{d}{2}; \quad I_1 = \frac{td^3 + t_1^3(b-t)}{12}; \quad S_1 = \frac{td^3 + t_1^3(b-t)}{6d}$$



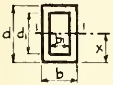
$$A = d^2 - d_1^2; \quad x = \frac{d}{2}; \quad I_1 = \frac{d^4 - d_1^4}{12}; \quad S_1 = \frac{d^4 - d_1^4}{6d}; \quad r_1 = \sqrt{\frac{d^2 + d_1^2}{12}}$$



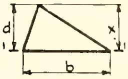
$$A = \frac{bd}{2}; \quad x = \frac{d}{3}; \quad x_1 = \frac{2d}{3}; \quad I_1 = \frac{bd^3}{36}; \quad S_1 = \frac{bd^2}{24}; \quad r_1 = \frac{d}{\sqrt{18}} = 0.235702d$$



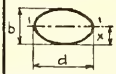
$$A = \frac{\pi bd}{4} = .7854bd; \quad x = \frac{d}{2}; \quad I_1 = \frac{\pi bd^3}{64} = 0.04909bd^3; \quad S_1 = \frac{\pi bd^2}{32} = 0.09818bd^2; \quad r_1 = \frac{d}{4}$$



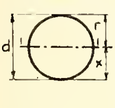
$$A = bd - b_1d_1; \quad x = \frac{d}{2}; \quad I_1 = \frac{bd^3 - b_1d_1^3}{12}; \quad S_1 = \frac{bd^3 - b_1d_1^3}{6d}; \quad r_1 = \sqrt{\frac{bd^3 - b_1d_1^3}{12A}}$$



$$A = \frac{bd}{2}; \quad x = d; \quad I_1 = \frac{bd^3}{12}; \quad S_1 = \frac{bd^2}{12}; \quad r_1 = \frac{d}{\sqrt{6}} = 0.408248d$$



$$A = \frac{\pi bd}{4} = .7854bd; \quad x = \frac{b}{2}; \quad I_1 = \frac{\pi db^3}{64} = 0.04909db^3; \quad S_1 = \frac{\pi db^2}{32} = 0.09818db^2; \quad r_1 = \frac{b}{4}$$



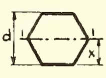
$$A = \frac{\pi d^2}{4} = \pi r^2 = 0.7864d^2 = 3.14159r^2$$

$$x = d \div 2 = r$$

$$I_1 = \frac{\pi d^4}{64} = \frac{\pi r^4}{4} = .04909d^4 = .7854r^4$$

$$S_1 = \frac{\pi d^3}{32} = \frac{\pi r^3}{4} = .09818d^3 = .7854r^3$$

$$r_1 = \frac{d}{4} = \frac{r}{2}$$

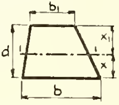


$$A = \frac{3}{2}d^2\tan 30° = .866d^2; \quad x = \frac{d}{2}$$

$$I_1 = \frac{A}{12}\left[\frac{d^2(1+2\cos^2 30°)}{4\cos^2 30°}\right] = .06d^4$$

$$S_1 = \frac{A}{6}\left[\frac{d(1+2\cos^2 30°)}{4\cos^2 30°}\right] = .12d^3$$

$$r_1 = \frac{d}{4}\sqrt{\frac{1+2\cos^2 30°}{3\cos^2 30°}} = .264d$$



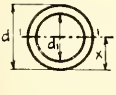
$$A = \frac{d(b+b_1)}{2}$$

$$x = \frac{d(b+2b_1)}{3(b+b_1)}; \quad x_1 = \frac{d(b_1+2b)}{3(b+b_1)}$$

$$I_1 = \frac{d^3(b^2+4bb_1+b_1^2)}{36(b+b_1)}$$

$$S_1 = \frac{d^2(b^2+4bb_1+b_1^2)}{12(b_1+2b)}$$

$$r_1 = \frac{d}{6(b+b_1)}\sqrt{2(b^2+4bb_1+b_1^2)}$$

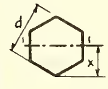


$$A = \frac{\pi(d^2-d_1^2)}{4}; \quad x = \frac{d}{2}$$

$$I_1 = \frac{\pi(d^4-d_1^4)}{64}$$

$$S_1 = \frac{\pi(d^4-d_1^4)}{32d}$$

$$r_1 = \frac{\sqrt{d^2+d_1^2}}{4}$$

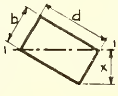


$$A = \frac{3}{2}d^2\tan 30°; \quad x = \frac{d}{2\cos 30°} = .577d$$

$$I_1 = \frac{A}{12}\left[\frac{d^2(1+2\cos^2 30°)}{4\cos^2 30°}\right] = .06d^4$$

$$S_1 = \frac{A}{6}\left[\frac{d(1+2\cos^2 30°)}{4\cos 30°}\right] = .104d^3$$

$$r_1 = \frac{d}{4}\sqrt{\frac{1+2\cos^2 30°}{3\cos^2 30°}} = .264d$$

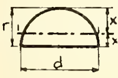


$$A = bd; \quad x = \frac{bd}{\sqrt{b^2+d^2}}$$

$$I_1 = \frac{b^3d^3}{6(b^2+d^2)}$$

$$S_1 = \frac{b^2d^2}{6\sqrt{b^2+d^2}}$$

$$r_1 = \frac{bd}{\sqrt{6(b^2+d^2)}}$$



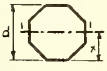
$$A = \frac{\pi r^2}{2} = 1.5708r^2; \quad x = \frac{4r}{3\pi}$$

$$x_1 = r\left(1 - \frac{4}{3\pi}\right) = 0.57559r$$

$$I_1 = r^4\left(\frac{\pi}{8} - \frac{8}{5\pi}\right) = 0.10976r^4$$

$$S_1 = \frac{r^3}{24}\frac{(9\pi^2-64)}{(3\pi-4)} = 0.19069r^3$$

$$r_1 = r\frac{\sqrt{9\pi^2-64}}{6\pi} = 0.26434r$$

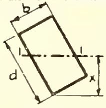


$$A = 2d^2\tan 22\tfrac{1}{2}° = 0.828d^2; \quad x = \frac{d}{2}$$

$$I_1 = \frac{A}{12}\left[\frac{d^2(1+2\cos^2 22\frac{1}{2}°)}{4\cos^2 22\frac{1}{2}°}\right] = .055d^4$$

$$S_1 = \frac{A}{6}\left[\frac{d(1+2\cos^2 22\frac{1}{2}°)}{4\cos 22\frac{1}{2}°}\right] = .109d^3$$

$$r_1 = \sqrt{\frac{1+2\cos^2 22\frac{1}{2}°}{3\cos^2 22\frac{1}{2}°}} = .257d$$

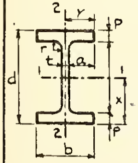


$$A = bd; \quad x = \frac{b\sin\theta + d\cos\theta}{2}$$

$$I_1 = \frac{bd(b^2\sin^2\theta + d^2\cos^2\theta)}{12}$$

$$S_1 = \frac{bd(b^2\sin^2\theta + d^2\cos^2\theta)}{6(b\sin\theta + d\cos\theta)}$$

$$r_1 = \sqrt{\frac{b^2\sin^2\theta + d^2\cos^2\theta}{12}}$$



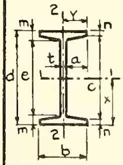
$$A = dt + 4ap + \frac{2}{3}r^2$$

$$x = \frac{d}{2}$$

$$y = \frac{b}{2}$$

$$I_1 = \frac{bd^3 - 2ac^3}{12} + 4\left[\frac{11}{2100}r^4 + \frac{1}{6}r^2\left(\frac{c}{2} - \frac{r}{5}\right)^2\right]$$

$$I_2 = \frac{2pb^3 + ct^3}{12} + 4\left[\frac{11}{2100}r^4 + \frac{1}{6}r^2\left(\frac{t}{2} + \frac{r}{5}\right)^2\right]$$



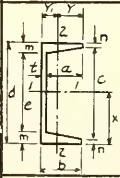
$$A = dt + 2a(m+n)$$

$$x = \frac{d}{2}$$

$$y = \frac{b}{2}$$

$$I_1 = \frac{bd^3 - \frac{a}{4(m-n)}(c^4 - e^4)}{12}$$

$$I_2 = \frac{2nb^3 + et^3 + \frac{m-n}{4a}(b^4 - t^4)}{12}$$



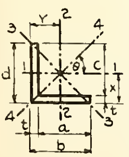
$$A = dt + a(m+n)$$

$$x = \frac{d}{2}$$

$$y_1 = \frac{b^2n + \frac{ct^2}{2} + \frac{a(m-n)}{3}(b+2t)}{A}; \quad y = by_1$$

$$I_1 = \frac{bd^3 - \frac{a}{8(m-n)}(c^4 - e^4)}{12}$$

$$I_2 = \frac{2nb^3 + et^3 + \frac{(m-n)}{2a}(b^4 - t^4)}{3} - Ay_1^2$$



$$A = t(b+c); \quad \theta = 45°$$

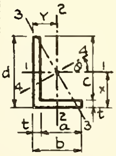
$$x = \frac{b^2 + ct}{2(b+c)}; \quad y = x$$

$$I_1 = \frac{t(b-x)^3 + bx^3 - a(x-t)^3}{3}$$

$$I_2 = I_1$$

$$I_3 = \frac{ct^3 + c^3t + 3ct(b-4x+2t)^2 + t^4 + 6t^2(2x-t)^2}{12}$$

$$I_4 = \frac{ct^3 + c^3t + 3ctb^2 + t^4}{12}$$



$$A = t(b+c); \quad x = \frac{t(b+2c) + c^2}{2(b+c)}; \quad y = \frac{t(2a+d) + a^2}{2(a+d)}$$

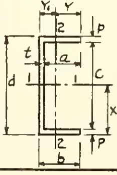
$$\mathrm{Tan}\,2\theta = \frac{t[(2y-t)d(d-2x) + a(2x-t)(b+t-2y)]}{2(I_1 - I_2)}$$

$$I_1 = \frac{t(d-x)^3 + bx^3 - a(x-t)^3}{3}$$

$$I_2 = \frac{t(b-y)^3 + dy^3 - c(y-t)^3}{3}$$

$$I_3 = \frac{I_2\cos^2\theta - I_1\sin^2\theta}{\cos 2\theta}$$

$$I_4 = \frac{I_1\cos^2\theta - I_2\sin^2\theta}{\cos 2\theta}$$



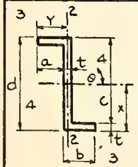
$$A = bd - c(b-t)$$

$$x = \frac{d}{2}$$

$$y_1 = b - y; \quad y = \frac{\frac{1}{2}[b^2d - c(b-t)^2]}{bd - c(b-t)}$$

$$I_1 = \frac{bd^3 - c^3(b-t)}{12}$$

$$I_2 = \frac{2b^3p + ct^3}{3} - Ay_1^2$$



$$A = t(d+2a); \quad x = \frac{d}{2}; \quad y = \frac{2b-t}{2}$$

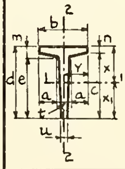
$$\mathrm{Tan}\,2\theta = \frac{(dt-t^2)(b^2-bt)}{I_1 - I_2}$$

$$I_1 = \frac{bd^3 - a(d-2t)^3}{12}$$

$$I_2 = \frac{d(b+a)^3 - 2a^3c - 6ab^2c}{12}$$

$$I_3 = \frac{I_2\cos^2\theta - I_1\sin^2\theta}{\cos 2\theta}$$

$$I_4 = \frac{I_1\cos^2\theta - I_2\sin^2\theta}{\cos 2\theta}$$

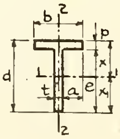


$$A = \frac{e(t+u)}{2} + mt + a(m+n); \quad y = \frac{b}{2}$$

$$x = \frac{6an^2 + 2a(m-n)(m+2n) + 3td^2 - e(t-u)(3d-e)}{6A}$$

$$I_1 = \frac{e^3(3u+t) + 4bm^3 - 2a(m-n)^3}{12} - A(x-m)^2$$

$$I_2 = \frac{nb^3 + (m-n)t^3 + eu^3}{12} + \frac{a(m-n)[2a^2 + (2a+3t)^2]}{36} + \frac{e(t-u)[(t-u)^2 + 2(t+2u)^2]}{144}$$

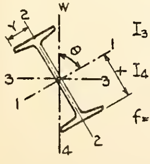


$$A = bp + et; \quad x_1 = d - x$$

$$x = \frac{d^2t + p^2(b-t)}{2A}; \quad y = \frac{b}{2}$$

$$I_1 = \frac{tx_1^3 + bx^3 - (b-t)(x-p)^3}{3}$$

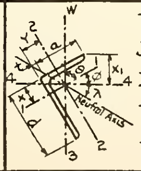
$$I_2 = \frac{pb^3 + ct^3}{12}$$



$$I_3 = I_1\sin^2\theta + I_2\cos^2\theta$$

$$I_4 = I_1\cos^2\theta + I_2\sin^2\theta$$

$$f = M\left(\frac{x}{I_1}\sin\theta + \frac{y}{I_2}\cos\theta\right)$$



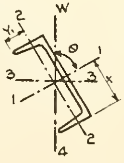
$$\mathrm{Tan}\,2\theta = \frac{2J}{I_2 - I_1}$$

$$J = \frac{t[d(2y-t)(d-2x) + a(2x-t)(a+2t-2y)]}{4}$$

$$I_3 = I_2 - J\tan\theta; \quad I_4 = I_1 + J\tan\theta$$

$$\mathrm{Tan}\,\lambda = \frac{x_1}{y_1} = \frac{I_4}{I_3}\cot\theta$$

$$f = M\left(\frac{x_1}{I_4}\sin\theta + \frac{y_1}{I_3}\cos\theta\right)$$



$$I_3 = I_1\sin^2\theta + I_2\cos^2\theta$$

$$I_4 = I_1\cos^2\theta + I_2\sin^2\theta$$

$$f = M\left(\frac{x}{I_1}\sin\theta + \frac{y_1}{I_2}\cos\theta\right)$$

FIREPROOFING

It is unfortunate that we cannot design for fire hazards as logically as we design for stress. It is certainly not good engineering to construct a building for an assumed live load of 500 lbs. sq. ft., when the structure is to be used as a hospital, where 40 lbs. sq. ft. might suffice. Neither is it good practice to provide for the same fire protection in the hospital that we would consider in a paint storage warehouse.

Fire hazards should be rated in accordance with the combustible contents of a structure. Similarly, the structure should be designed with these fire hazards in mind. Fire-resistive structures should be evaluated in terms of their ability to withstand temperatures produced by the burning out of their combustible contents, all in relation to the time-temperature curve.

All fire-resistive buildings, including such portions as are used for the storage or handling of unusual quantities of combustible materials, should be fireproofed to protect them against the maximum fire hazards found within any section having fire separation from the remainder of the building, in acordance with the measured quantities of contained combustible materials, including wood floor, covering, and wood trim. The maximum fire hazard, based on the weight of combustible materials, should be determined from the floor area or fire division of the building considered. The burning-out tests of the Bureau of Standards, with office occupancy and record storage, wood furniture and shelving, indicates the following equivalent fire hazard will approximately apply. Metal furniture, files and shelving show a substantial reduction of fire hazard.

10 lbs. sq. ft. constitutes 1 hr. fire hazard
15 lbs. sq. ft. constitutes 1½ hr. fire hazard
20 lbs. sq. ft. constitutes 2 hr. fire hazard
30 lbs. sq. ft. constitutes 3 hr. fire hazard
40 lbs. sq. ft. constitutes 4½ hr. fire hazard
50 lbs. sq. ft. constitutes 6 hr. fire hazard
60 lbs. sq. ft. constitutes 7½ hr. fire hazard

Weighted occupancy tests indicate that the average weight of combustible material is remarkably low. Factually, little or no damage is suffered in the frame of a building, from fire, even in those cases where loss of life has been great.

It is not generally known, perhaps, but structural steel is approximately 25% stronger at a temperature of 550° F. than it is at normal temperature. Its strength at 800° F. is about the same as at normal temperature. At 1000° F. its strength in compression is approximately the same as the maximum permissible working stress in columns. It is evident that structural steel should be insulated against temperature rises above 800° F., and that if the insulating material is effective within the time period no temperatures less than the amount given can cause distress. When higher stresses or special steels are used, proper consideration should be given to extra insulation.

The insulating material used should be so applied that temperature differences in the steel in any cross section should not set up any serious internal or buckling stresses; such variation as exists should be symmetrical about axes of compression members. Insulating material should continue to function within the temperature range of its use, so applied that it will not crack, spall or buckle to seriously expose the steel to direct heat from fire. If the insulation contemplates utilization of air spaces, fire stops should be placed at ends of members.

The consideration of insulation materials to be used as fireproofing media is receiving careful attention at this moment. It is quite within the bounds of possibility that we may soon be enabled to design for fire protection as scientifically as we now design our structural members to carry stress.

SUGGESTED FIREPROOFING REQUIREMENTS

PROTECTION OF STRUCTURAL PARTS

MEMBER TO BE PROTECTED	FIREPROOFING MATERIAL	Minimum Thickness for Hour Ratings Shown			
		4	3	2	1
Steel or Cast Iron Columns; Projecting Steel Beams or Girder Flanges; All Members of Primary Trusses	Grade A Concrete.....	2	2	1½	1
	Grade B Concrete.....	3	2½	2	1½
	Pneumatically placed Concrete	2	1½	1	¾
	Brick of Clay, Shale, Concrete, or Sand-Lime	3¾	3¾	2¼	1¼
	Clay Tile, Clay Tile and Concrete, or Concrete Block..........	4	3	2	2
	Solid Gypsum Blocks..	2 pl	2 pl	2	2
	Hollow Gypsum Blocks	3 pl	3	2	2
	Poured Gypsum.......	2	1½	1	1
	Gypsum-Vermiculite Plaster on metal or Gypsum Lath........	1⅛	1	⅞	¾
Webs of Steel Beams and Girders	Grade A Concrete.....	2	1½	1	1
	Grade B Concrete.....	3	2½	1½	1
	Pneumatically placed Concrete	2	1½	1	¾
	Brick, of Clay, Shale, Concrete, or Sand-Lime	3¾	2¼	2¼	2¼
	Clay Tile, Clay Tile and Concrete, or Concrete Block	3	2	2	2
	Solid Gypsum Block...	2 pl	2	2	2
	Hollow Gypsum Blocks	3 pl	2	2	2
	Poured Gypsum.......	2	1½	1	1
	Gypsum-Vermiculite Plaster on Metal Lath..........	1	⅞	¾	¾
Reinforced Concrete Beams, Columns, Girders & Trusses	Grade A Concrete.....	1½	1½	1½	1
	Grade B Concrete.....	2	1½	1½	1
Reinforced Concrete Joist	Grade A Concrete.....	1¼	1¼	1	¾
	Grade B Concrete.....	1¾	1½	1	¾
Ceiling Protection under Steel Joist having 2½″ concrete slab above	Pneumatically placed Plaster	1½	1	¾	¾
	Wood-Fibered Gypsum .	2	1	¾	¾
	Sand-Gypsum Plaster ..	2	1½	¾	¾
	Gypsum-Vermiculite Pl.	1	⅞	¾	¾
	Concrete-Clay Products	2	1½	1	¾
Ceiling Protection of Roof Trusses	Metal lath-Gypsum or Cement Plaster.......	2	1½	1	¾
	Metal lath-Gypsum-Vermiculite Plaster....	1	⅞	¾	¾
Reinforcing and Tie Rods in Slabs	Grade A Concrete.....	1	1	¾	¾
	Grade B Concrete.....	1¼	1	1	¾
	Gypsum	1	1	¾	¾

WALLS AND PARTITIONS

MATERIAL	CONSTRUCTION		Minimum Thickness for Hour Ratings Shown			
			4	3	2	1
Brick of Clay, Shale, Sand-Lime, or Concrete, or Plain Concrete	Solid, Unplastered......		8			4
	Solid, Plastered...........		9		5	
	Hollow, rowlock, unpl......		12	10	8	
	Hollow, rowlock, pls........		9			
Hollow Clay Tile Wall	End or Side-1 cell, pls......					3
	8″ Wall-2 cells, unpls...		16	12		6
	8″ Wall-2 cells, pls.....		13	9	7	
Hollow Clay Tile A.S.T.M. Load Bearing	End or Side-2 cells, unpls...				6	
	2 cells, pls.....				5	
	8″ Wall-3 cells, unpls...		12			
	8″ Wall-3 cells, pls.....			8½		
	8″ Wall-3 cells, pls.....		9			
Combination of Brick & A.S.T.M. Load Bearing Tile, or Hollow Concrete Block or Tile	4″ Brick and 4″ Tile plastered one side.........		9			
Concrete Block or Tile	Aggregate Exp. Slag Burned Clay Shale, Cinders	Unplastered..			8	4
		Plas. 1 side...		8½	4½	
		Unplastered..	12	8		
		Plas. 1 side...	9			
		Unplastered..	8			
	Other Aggregates	Unplastered..			8	4
		Plas. 1 side...		9	5	
		Unplastered..	12	8		
		Plas. 1 side...	9			
		Unplastered..	8			
Solid Concrete	Reinf, not less than 0.2%...		6	5	4	2
Solid Pneumatically Placed Concrete	Reinf, not less than 0.2%...		5	4	3	2
Hollow Gypsum Blocks	Unplastered..............		6	5	4	3
	Plastered, each side........		5	4	4	3
Hollow Wall of Pneumatic. Placed Reinforced Concrete	Outer shell 2″ thick for 10″ walls, and 1½″ thick for 8″ walls..........		10	8		
Solid Gypsum or Portland Cem., Pls.	Incombustible Studs........					2
					2	
Hollow Stud Partition with Gypsum or Cement Plaster, or Gunite Each Side	Incombustible Studs, ¾″ pls.					3
	Incombustible Studs, 1″ pls..				4½	
	Wood Studs, ¾″ pls.......					3
	Wood Studs, 1″ pls........				5	
	Wood Studs, ½″ pls.......					3

FIRE-RESISTIVE RATING OF FLOORS:

(a) A 4-hour fire resistive floor shall consist of concrete, gypsum or solid masonry slabs or arches not less than 4″ in thickness, or of hollow masonry slabs or arches not less than 4″ in thickness with top slab not less than 2″ thick, or steel joist construction with 2½″ slab over and ceiling protection as specified.

(b) A 3-hour fire-resistive floor shall consist of concrete, gypsum or solid masonry slabs or aches not less than 3″ in thickness, or of hollow masonry slabs or arches not less than 4″ in thickness with top slab not less than 1½″ thick, or steel joist construction with slab and ceiling as specified.

(c) A 2-hour fire resistive floor shall consist of concrete, gypsum or solid masonry slabs or arches not less than 2½″ in thickness, or of hollow masonry slabs or arches not less than 3″ in thickness with top slab not less than 1″ thick, or steel joist construction with slab and ceiling as specified.

(d) A 1-hour fire resistive floor shall consist of concrete, gypsum or solid masonry slabs or arches not less than 2½″ in thickness, or of hollow masonry slabs or arches not less than 3″ in thickness, or steel joist construction with slab and ceiling as specifiied.

SPECIAL:

Steel plate floors, with ceiling and slab protection, have been approved by the Underwriters.

CLASSIFICATION:

Fire-resistive construction (often called "Fireproof") is the highest type classified. Buildings of this type more than 8 stories, or 85′ in height, usually require 4-hour protection for columns and primary beams, with 3-hour floors. Structures less than 8 stories usually have 3-hour protection for beams and columns, with 2-hour floors.

RECOMMENDED LIVE LOADS

	Lbs. per sq. ft.
Apartments	40
Armories	150
Auditoriums—Fixed seats	70
Movable seats	100
Balconies and Galleries—Fixed seats	70
Movable seats	100
Dance Halls	120
Drill Rooms	150
Dwellings	40
Exterior Balconies	100
Fire Escapes	100
Garages—All Types of Vehicles	100
Passenger Cars Only	80
Gymnasiums	100
Hospitals—Wards and Rooms	40
Corridors and Public Rooms	100
Hotels—Guest Rooms and Corridors	40
Public Rooms and Public Corridors	100
Libraries—Reading Rooms	60
Corridors	100
Stack Rooms	125
Loft Buildings	100
Manufacturing—Light	75
Heavy	125
Marquise	60
Offices	50
Printing Plants—Press Rooms	150
Composing and Linotype Rooms	100
Public Rooms	100
Rest Rooms	50
Reviewing Stands, Bleachers, etc	100
Roof Loads—Rise Less Than 1 to 4	30
Schools—Class Rooms	40
Corridors	100
Sidewalks—800 lbs. Concentrated or	250
Skating Rinks	100
Stairways	100
Stage Floor—Theatre	120
Storage—Light	125
Heavy, to be determined by occupancy, but never less than	250
Stores—Retail (Light Merchandise)	100
Wholesale (Light Merchandise)	100

REDUCTION OF COLUMN LIVE LOADS.

Warehouse and Storage Bldgs.

Carrying roof	0 per cent
Carrying 1 floor and roof	0 per cent
Carrying 2 floors and roof	5 per cent
Carrying 3 floors and roof	10 per cent
Carrying 4 floors and roof	15 per cent
Carrying 5 floors and roof	20 per cent

Manufacturing Bldgs., Stores, Garages.

Carrying roof	0 per cent
Carrying 1 floor and roof	0 per cent
Carrying 2 floors and roof	10 per cent
Carrying 3 floors and roof	20 per cent
Carrying 4 floors and roof	30 per cent

Other Types of Buildings.

Carrying roof	0 per cent
Carrying 1 floor and roof	0 per cent
Carrying 2 floors and roof	10 per cent
Carrying 3 floors and roof	20 per cent
Carrying 4 floors and roof	30 per cent
Carrying 5 floors and roof	40 per cent
Carrying 6 floors and roof	45 per cent
Carrying 7 or more floors and roof	50 per cent

Live load on girders (not beams or slabs) may be reduced 5% for tributary floor area of 100 sq. ft., 10% for 200 sq. ft., and 15% for tributary area of 300 sq. ft. or more.

WEIGHTS OF BUILDING MATERIALS

	Lbs. Cu. Ft.
Asphaltum	100
Brick, Common, piled	125
Common, laid, ⅜″ joints	120
Pressed, laid	130
Cinders, dry	45
Concrete, Cinder, used for filling	60
Cinder, structural	110
Burned aggregate, plain	115
Stone or gravel, plain	144
Stone or gravel, reinforced	150
Building tile, 60% solid	87
Building tile, 55% solid	79
Cast Iron	450
Cement, Natural	59
Portland	73
Earth, Common loam, dry and loose	76
Common earth, dry and packed	95
Clay and gravel, dry and loose	100
Clay, damp, plastic	110
Wet mud	120
Glass	160
Granite, Masonry, dressed	165
Masonry, rubble	155
Gravel, dry	120
Limestone, Masonry, dressed	160
Marble, Masonry, dressed	170
Mortar, hard, cement	135
Mortar, hard, lime	105
Steel	490
Sand, dry	100
Sand, wet	120
Terra Cotta, brick fill	120
Timber, Seasoned Ash	40
Cedar	22
Cypress	30
Elm	45
Fir	32
Hickory	49
Maple	43
Oak, red	41
Oak, white	46
Pine, Oregon	32
Pine, long leaf yellow	48
Walnut	38
Water, fresh, at 60° F	62½

	Lbs. Sq. Ft.
Ceilings, Plaster on tile or concrete	5
Metal lath and plaster, suspended	10
Wood lath and plaster	8
Plaster board, unplastered	3
Gypsum ceiling tile, 2″, unplastered	9
Pressed steel	2
Floors, Cinder concrete fill, per inch	7
Cement finish, per inch	12
Maple, ⅞″, on sheathing, 2″ cinder fill, without ceiling	18
Oak, ⅞″, on sheathing, wood joist 16″ cts., no ceiling	11
Gypsum floor slab, per inch	5
Asphalt mastic	5
Wood block, 3″, on ½″ bed	21
Ceramic tile, on 1″ mortar bed	23
Terrazzo, 1″, on ½″ bed	18
Linoleum, ¼″	2
Marble, 1″, on ½″ bed	20
Partitions, 2x4 stud, wood lath, ⅝″ plaster both sides	16
2x4 stud, plaster board, ⅝″ plaster both sides	16
2″ plaster, channel studs, metal lath	20
4″ plaster, channel studs, metal lath	32
4″ hollow plaster, metal lath	22
2″ solid gypsum block, both sides plastered	16
3″ hollow gypsum block, both sides plastered	16
3″ solid gypsum block, both sides plastered	19
4″ hollow gypsum block, both sides plastered	19
5″ hollow gypsum block, both sides plastered	22
6″ hollow gypsum block, both sides plastered	23
3″ clay tile, both sides plastered	27
4″ clay tile, both sides plastered	28
6″ clay tile, both sides plastered	35
8″ clay tile, both sides plastered	41
10″ clay tile, both sides plastered	45
Marble wainscoating, 1″	15
Steel partitions	4
Roofs, Five ply, felt and gravel	6
Four ply, felt and gravel	5
Three ply, felt ready roofing	1
Cement tile	16
Slate, ¼″	10
Sheathing, 1″ yellow pine	4
Spanish tile	19
Ludowici tile	10
Gypsum slab, 2½″	13
Skylights, metal, wire glass	6

WALLS.

		Un-plastered	Plaster 1 Side	Plaster 2 Sides
Brick—	9″	85	90	95
	13″	120	125	130
	17″	165	170	175
	21″	205	210	215
	26″	245	250	255
Tile—	6″	30	35	40
	8″	33	38	43
	10″	40	45	50
	12″	45	50	55

WALLS.

		Un-plastered	Plaster 1 Side
Brick	4″—Tile 4″	60	65
	4″— " 8″	75	80
	9″— " 4″	100	105
	9″— " 9″	115	120
Limestone	4″—Brick 9″	140	145
	4″—Brick 13″	175	180
	4″—Tile 8″	90	95
	4″—Tile 12″	100	105

Weight of walls in lbs. sq. ft.

COURTESY, "AMERICAN INSTITUTE OF STEEL CONSTRUCTION"

WEIGHTS AND SPECIFIC GRAVITIES

Substance	Weight Lb. per Cu. Ft.	Specific Gravity
ASHLAR MASONRY		
Granite, syenite, gneiss	165	2.3-3.0
Limestone, marble	160	2.3-2.8
Sandstone, bluestone	140	2.1-2.4
MORTAR RUBBLE MASONRY		
Granite, syenite, gneiss	155	2.2-2.8
Limestone, marble	150	2.2-2.6
Sandstone, bluestone	130	2.0-2.2
DRY RUBBLE MASONRY		
Granite, syenite, gneiss	130	1.9-2.3
Limestone, marble	125	1.9-2.1
Sandstone, bluestone	110	1.8-1.9
BRICK MASONRY		
Pressed brick	140	2.2-2.3
Common brick	120	1.8-2.0
Soft brick	100	1.5-1.7
CONCRETE MASONRY		
Cement, stone, sand	144	2.2-2.4
Cement, slag, etc.	130	1.9-2.3
Cement, cinder, etc.	100	1.5-1.7
VARIOUS BUILDING MATERIALS		
Ashes, cinders	40-45	-------
Cement, portland, loose	90	-------
Cement, portland, set	183	2.7-3.2
Lime, gypsum, loose	53-64	-------
Mortar, set	103	1.4-1.9
Slags, bank slag	67-72	-------
Slags, bank screenings	98-117	-------
Slags, machine slag	96	-------
Slags, slag sand	49-55	-------
EARTH, ETC., EXCAVATED		
Clay, dry	63	-------
Clay, damp, plastic	110	-------
Clay and gravel, dry	100	-------
Earth, dry, loose	76	-------
Earth, dry, packed	95	-------
Earth, moist, loose	78	-------
Earth, moist, packed	96	-------
Earth, mud, flowing	108	-------
Earth, mud, packed	115	-------
Riprap, limestone	80-85	-------
Riprap, sandstone	90	-------
Riprap, shale	105	-------
Sand, gravel, dry, loose	90-105	-------
Sand, gravel, dry, packed	100-120	-------
Sand, gravel, dry, wet	118-120	-------
EXCAVATIONS IN WATER		
Sand or gravel	60	-------
Sand or gravel and clay	65	-------
Clay	80	-------
River mud	90	-------
Soil	70	-------
Stone riprap	65	-------

Substance	Weight Lb. per Cu. Ft.	Specific Gravity
MINERALS		
Asbestos	153	2.1-2.8
Barytes	281	4.50
Basalt	184	2.7-3.2
Bauxite	159	2.55
Borax	109	1.7-1.8
Chalk	137	1.8-2.6
Clay, marl	137	1.8-2.6
Dolomite	181	2.9
Feldspar, orthoclase	159	2.5-2.6
Gneiss, serpentine	159	2.4-2.7
Granite, syenite	175	2.5-3.1
Greenstone, trap	187	2.8-3.2
Gypsum, alabaster	159	2.3-2.8
Hornblende	187	3.0
Limestone, marble	165	2.5-2.8
Magnesite	187	3.0
Phosphate rock, apatite	200	3.2
Porphyry	172	2.6-2.9
Pumice, natural	40	0.37-0.90
Quartz, flint	165	2.5-2.8
Sandstone, bluestone	147	2.2-2.5
Shale, slate	175	2.7-2.9
Soapstone, talc	169	2.6-2.8
STONE, QUARRIED, PILED		
Basalt, granite, gneiss	96	-------
Limestone, marble, quartz	95	-------
Sandstone	82	-------
Shale	92	-------
Greenstone, hornblende	107	-------
BITUMINOUS SUBSTANCES		
Asphaltum	81	1.1-1.5
Coal, anthracite	97	1.4-1.7
Coal, bituminous	84	1.2-1.5
Coal, lignite	78	1.1-1.4
Coal, peat, turf, dry	47	0.65-0.85
Coal, charcoal, pine	23	0.28-0.44
Coal, charcoal, oak	33	0.47-0.57
Coal, coke	75	1.0-1.4
Graphite	131	1.9-2.3
Paraffine	56	0.87-0.91
Petroleum	54	0.87
Petroleum, refined	50	0.79-0.82
Petroleum, benzine	46	0.73-0.75
Petroleum, gasoline	42	0.66-0.69
Pitch	69	1.07-1.15
Tar, bituminous	75	1.20
COAL AND COKE, PILED		
Coal, anthracite	47-58	-------
Coal, bituminous, lignite	40-54	-------
Coal, peat, turf	20-26	-------
Coal, charcoal	10-14	-------
Coal, coke	23-32	-------

The specific gravities of solids and liquids refer to water at 4°C., those of gases to air at 0°C. and 760 mm. pressure. The weights per cubic foot are derived from average specific gravities, except where stated that weights are for bulk, heaped or loose material, etc.

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WEIGHTS AND SPECIFIC GRAVITIES

Substance	Weight Lb. per Cu. Ft.	Specific Gravity
METALS, ALLOYS, ORES		
Aluminum, cast, hammered	165	2.55-2.75
Aluminum, bronze	481	7.7
Brass, cast, rolled	534	8.4-8.7
Bronze, 7.9 to 14% Sn	509	7.4-8.9
Copper, cast, rolled	556	8.8-9.0
Copper ore, pyrites	262	4.1-4.3
Gold, cast, hammered	1205	19.25-19.3
Iron, cast, pig	450	7.2
Iron, wrought	485	7.6-7.9
Iron, steel	490	7.8-7.9
Iron, spiegel-eisen	468	7.5
Iron, ferro-silicon	437	6.7-7.3
Iron ore, hematite	325	5.2
Iron ore, hematite in bank	160-180	-------
Iron ore, hematite loose	130-160	-------
Iron ore, limonite	237	3.6-4.0
Iron ore, magnetite	315	4.9-5.2
Iron slag	172	2.5-3.0
Lead	710	11.37
Lead ore, galena	465	7.3-7.6
Manganese	475	7.2-8.0
Manganese ore, pyrolusite	259	3.7-4.6
Mercury	849	13.6
Nickel	565	8.9-9.2
Nickel, monel metal	556	8.8-9.0
Platinum, cast, hammered	1330	21.1-21.5
Silver, cast, hammered	656	10.4-10.6
Tin, cast, hammered	459	7.2-7.5
Tin ore, cassiterite	418	6.4-7.0
Zinc, cast, rolled	440	6.9-7.2
Zinc ore, blende	253	3.9-4.2
VARIOUS SOLIDS		
Cereals, oats bulk	32	-------
Cereals, barley bulk	39	-------
Cereals, corn, rye bulk	48	-------
Cereals, wheat bulk	48	-------
Hay and Straw bales	20	-------
Cotton, Flax, Hemp	93	1.47-1.50
Fats	58	0.90-0.97
Flour, loose	28	0.40-0.50
Flour, pressed	47	0.70-0.80
Glass, common	156	2.40-2.60
Glass, plate or crown	161	2.45-2.72
Glass, crystal	184	2.90-3.00
Leather	59	0.86-1.02
Paper	58	0.70-1.15
Potatoes, piled	42	-------
Rubber, caoutchouc	59	0.92-0.96
Rubber goods	94	1.0-2.0
Salt, granulated, piled	48	-------
Saltpeter	67	-------
Starch	96	1.53
Sulphur	125	1.93-2.07
Wool	82	1.32

Substance	Weight Lb. per Cu. Ft.	Specific Gravity
TIMBER, U. S. SEASONED		
Moisture Content by Weight:		
Seasoned timber 15 to 20%		
Green timber up to 50%		
Ash, white, red	40	0.62-0.65
Cedar, white, red	22	0.32-0.38
Chestnut	41	0.66
Cypress	30	0.48
Fir, Douglas spruce	32	0.51
Fir, eastern	25	0.40
Elm, white	45	0.72
Hemlock	29	0.42-0.52
Hickory	49	0.74-0.84
Locust	46	0.73
Maple, hard	43	0.68
Maple, white	33	0.53
Oak, chestnut	54	0.86
Oak, live	59	0.95
Oak, red, black	41	0.65
Oak, white	46	0.74
Pine, Oregon	32	0.51
Pine, red	30	0.48
Pine, white	26	0.41
Pine, yellow, long-leaf	44	0.70
Pine, yellow, short-leaf	38	0.61
Poplar	30	0.48
Redwood, California	26	0.42
Spruce, white, black	27	0.40-0.46
Walnut, black	38	0.61
Walnut, white	26	0.41
VARIOUS LIQUIDS		
Alcohol, 100%	49	0.79
Acids, muriatic 40%	75	1.20
Acids, nitric 91%	94	1.50
Acids, sulphuric 87%	112	1.80
Lye, soda 66%	106	1.70
Oils, vegetable	58	0.91-0.94
Oils, mineral, lubricants	57	0.90-0.93
Water, 4°C. max. density	62.428	1.0
Water, 100°C.	59.830	0.9584
Water, ice	56	0.88-0.92
Water, snow, fresh fallen	8	.125
Water, sea water	64	1.02-1.03
GASES		
Air, 0°C. 760 mm.	.08071	1.0
Ammonia	.0478	0.5920
Carbon dioxide	.1234	1.5291
Carbon monoxide	.0781	0.9673
Gas, illuminating	.028-.036	0.35-0.45
Gas, natural	.038-.039	0.47-0.48
Hydrogen	.00559	0.0693
Nitrogen	.0784	0.9714
Oxygen	.0892	1.1056

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LENGTH OF CIRCULAR ARCS FOR UNIT RADIUS

By the use of this table, the length of any arc may be found if the length of the radius and the angle of the segment are known.

Example:—Required the length of arc of segment of 32° 15′ 27″ with radius of 24 feet 3 inches.

From table: Length of arc (Radius 1) for 32° = .5585054
15′ = .0043633
27″ = .0001309
.5629996

.5629996 × 24.25 (length of radius) = 13.65 feet.

DEGREES						MINUTES		SECONDS	
1°	.017 4533	61°	1.064 6508	121°	2.111 8484	1′	.000 2909	1″	.000 0048
2	.034 9066	62	1.082 1041	122	2.129 3017	2	.000 5818	2	.000 0097
3	.052 3599	63	1.099 5574	123	2.146 7550	3	.000 8727	3	.000 0145
4	.069 8132	64	1.117 0107	124	2.164 2083	4	.001 1636	4	.000 0194
5	.087 2665	65	1.134 4640	125	2.181 6616	5	.001 4544	5	.000 0242
6	.104 7198	66	1.151 9173	126	2.199 1149	6	.001 7453	6	.000 0291
7	.122 1730	67	1.169 3706	127	2.216 5682	7	.002 0362	7	.000 0339
8	.139 6263	68	1.186 8239	128	2.234 0214	8	.002 3271	8	.000 0388
9	.157 0796	69	1.204 2772	129	2.251 4747	9	.002 6180	9	.000 0436
10	.174 5329	70	1.221 7305	130	2.268 9280	10	.002 9089	10	.000 0485
11	.191 9862	71	1.239 1838	131	2.286 3813	11	.003 1998	11	.000 0533
12	.209 4395	72	1.256 6371	132	2.303 8346	12	.003 4907	12	.000 0582
13	.226 8928	73	1.274 0904	133	2.321 2879	13	.003 7815	13	.000 0630
14	.244 3461	74	1.291 5436	134	2.338 7412	14	.004 0724	14	.000 0679
15	.261 7994	75	1.308 9969	135	2.356 1945	15	.004 3633	15	.000 0727
16	.279 2527	76	1 326 4502	136	2.373 6478	16	.004 6542	16	.000 0776
17	.296 7060	77	1.343 9035	137	2.391 1011	17	.004 9451	17	.000 0824
18	.314 1593	78	1.361 3568	138	2.408 5544	18	.005 2360	18	.000 0873
19	.331 6126	79	1.378 8101	139	2.426 0077	19	.005 5269	19	.000 0921
20	.349 0659	80	1.396 2634	140	2.443 4610	20	.005 8178	20	.000 0970
21	.366 5191	81	1.413 7167	141	2.460 9142	21	.006 1087	21	.000 1018
22	.383 9724	82	1.431 1700	142	2.478 3675	22	.006 3995	22	.000 1067
23	.401 4257	83	1.448 6233	143	2.495 8208	23	.006 6904	23	.000 1115
24	.418 8790	84	1.466 0766	144	2.513 2741	24	.006 9813	24	.000 1164
25	.436 3323	85	1.483 5299	145	2.530 7274	25	.007 2722	25	.000 1212
26	.453 7856	86	1.500 9832	146	2.548 1807	26	.007 5631	26	.000 1261
27	.471 2389	87	1.518 4364	147	2.565 6340	27	.007 8540	27	.000 1309
28	.488 6922	88	1.535 8897	148	2.583 0873	28	.008 1449	28	.000 1357
29	.506 1455	89	1.553 3430	149	2.600 5406	29	.008 4358	29	.000 1406
30	.523 5988	90	1.570 7963	150	2.617 9939	30	.008 7266	30	.000 1454
31	.541 0521	91	1.588 2496	151	2.635 4472	31	.009 0175	31	.000 1503
32	.558 5054	92	1.605 7029	152	2.652 9005	32	.009 3084	32	.000 1551
33	.575 9587	93	1.623 1562	153	2.670 3538	33	.009 5993	33	.000 1600
34	.593 4119	94	1.640 6095	154	2.687 8070	34	.009 8902	34	.000 1648
35	.610 8652	95	1.658 0628	155	2.705 2603	35	.010 1811	35	.000 1697
36	.628 3185	96	1.675 5161	156	2.722 7136	36	.010 4720	36	.000 1745
37	.645 7718	97	1.692 9694	157	2.740 1669	37	.010 7629	37	.000 1794
38	.663 2251	98	1.710 4227	158	2.757 6202	38	.011 0538	38	.000 1842
39	.680 6784	99	1.727 8760	159	2.775 0735	39	.011 3446	39	.000 1891
40	.698 1317	100	1.745 3293	160	2.792 5268	40	.011 6355	40	.000 1939
41	.715 5850	101	1.762 7825	161	2.809 9801	41	.011 9264	41	.000 1988
42	.733 0383	102	1.780 2358	162	2.827 4334	42	.012 2173	42	.000 2036
43	.750 4916	103	1.797 6891	163	2.844 8867	43	.012 5082	43	.000 2085
44	.767 9449	104	1.815 1424	164	2.862 3400	44	.012 7991	44	.000 2133
45	.785 3982	105	1.832 5957	165	2.879 7933	45	.013 0900	45	.000 2182
46	.802 8515	106	1.850 0490	166	2.897 2466	46	.013 3809	46	.000 2230
47	.820 3047	107	1.867 5023	167	2.914 6999	47	.013 6717	47	.000 2279
48	.837 7580	108	1.884 9556	168	2.932 1531	48	.013 9626	48	.000 2327
49	.855 2113	109	1.902 4089	169	2.949 6064	49	.014 2535	49	.000 2376
50	.872 6646	110	1.919 8622	170	2 967 0597	50	.014 5444	50	.000 2424
51	.890 1179	111	1.937 3155	171	2.984 5130	51	.014 8353	51	.000 2473
52	.907 5712	112	1.954 7688	172	3.001 9663	52	.015 1262	52	.000 2521
53	.925 0245	113	1.972 2221	173	3.019 4196	53	.015 4171	53	.000 2570
54	.942 4778	114	1.989 6753	174	3.036 8729	54	.015 7080	54	.000 2618
55	.959 9311	115	2.007 1286	175	3.054 3262	55	.015 9989	55	.000 2666
56	.977 3844	116	2.024 5819	176	3.071 7795	56	.016 2897	56	000 2715
57	.994 8377	117	2.042 0352	177	3.089 2328	57	.016 5806	57	000 2763
58	1.012 2910	118	2.059 4885	178	3.106 6861	58	.016 8715	58	.000 2812
59	1.029 7443	119	2.076 9418	179	3.124 1394	59	.017 1624	59	000 2860
60	1.047 1976	120	2.094 3951	180	3.141 5927	60	.017 4533	60	000 2909

COURTESY, "AMERICAN INSTITUTE OF STEEL CONSTRUCTION"

WIRE AND SHEET METAL GAGES

IN DECIMALS OF AN INCH

Name of Gage	United States Standard Gage*		American Steel & Wire Co., and John A. Roebling Sons Co.	American or Brown & Sharpe Wire Gage	New Birmingham Standard Sheet & Hoop Gage	British Imperial or English Legal Standard Wire Gage	Birmingham or Stubs Iron Wire Gage	Name of Gage
Principal Use	Uncoated Steel Sheets and Light Plates		Steel Wire except Music Wire	Non-Ferrous Sheets and Wire	Iron and Steel Sheets and Hoops	Wire	Strips, Bands, Hoops and Wire	Principal Use
Gage No.	Weight Lb. per Sq. Ft.	Approx. Thickness Inches	Thickness, Inches					Gage No.
7/0's	20.00	.4902	.4900		.6666	.500		7/0's
6/0's	18.75	.4596	.4615	.5800	.625	.464		6/0's
5/0's	17.50	.4289	.4305	.5165	.5883	.432	.500	5/0's
4/0's	16.25	.3983	.3938	.4600	.5416	.400	.454	4/0's
3/0's	15.00	.3676	.3625	.4096	.500	.372	.425	3/0's
2/0's	13.75	.3370	.3310	.3648	.4452	.348	.380	2/0's
0	12.50	.3064	.3065	.3249	.3964	.324	.340	0
1	11.25	.2757	.2830	.2893	.3532	.300	.300	1
2	10.625	.2604	.2625	.2576	.3147	.276	.284	2
3	10.00	.2451	.2437	.2294	.2804	.252	.259	3
4	9.375	.2298	.2253	.2043	.250	.232	.238	4
5	8.75	.2145	.2070	.1819	.2225	.212	.220	5
6	8.125	.1991	.1920	.1620	.1981	.192	.203	6
7	7.50	.1838	.1770	.1443	.1764	.176	.180	7
8	6.875	.1685	.1620	.1285	.1570	.160	.165	8
9	6.25	.1532	.1483	.1144	.1398	.144	.148	9
10	5.625	.1379	.1350	.1019	.1250	.128	.134	10
11	5.00	.1225	.1205	.0907	.1113	.116	.120	11
12	4.375	.1072	.1055	.0808	.0991	.104	.109	12
13	3.75	.0919	.0915	.0720	.0882	.092	.095	13
14	3.125	.0766	.0800	.0641	.0785	.080	.083	14
15	2.8125	.0689	.0720	.0571	.0699	.072	.072	15
16	2.50	.0613	.0625	.0508	.0625	.064	.065	16
17	2.25	.0551	.0540	.0453	.0556	.056	.058	17
18	2.00	.0490	.0475	.0403	.0495	.048	.049	18
19	1.75	.0429	.0410	.0359	.0440	.040	.042	19
20	1.50	.0368	.0348	.0320	.0392	.036	.035	20
21	1.375	.0337	.0318	.0285	.0349	.032	.032	21
22	1.25	.0306	.0286	.0253	.0313	.028	.028	22
23	1.125	.0276	.0258	.0226	.0278	.024	.025	23
24	1.00	.0245	.0230	.0201	.0248	.022	.022	24
25	.875	.0214	.0204	.0179	.0220	.020	.020	25
26	.75	.0184	.0181	.0159	.0196	.018	.018	26
27	.6875	.0169	.0173	.0142	.0175	.0164	.016	27
28	.625	.0153	.0162	.0126	.0156	.0148	.014	28
29	.5625	.0138	.0150	.0113	.0139	.0136	.013	29
30	.50	.0123	.0140	.0100	.0123	.0124	.012	30
31	.4375	.0107	.0132	.0089	.0110	.0116	.010	31
32	.4062	.0100	.0128	.0080	.0098	.0108	.009	32
33	.375	.0092	.0118	.0071	.0087	.0100	.008	33
34	.3438	.0084	.0104	.0063	.0077	.0092	.007	34
35	.3125	.0077	.0095	.0056	.0069	.0084	.005	35
36	.2812	.0069	.0090	.0050	.0061	.0076	.004	36
37	.2656	.0065	.0085	.0045	.0054	.0068		37
38	.25	.0061	.0080	.0040	.0048	.0060		38
39	.2344	.0057	.0075	.0035	.0043	.0052		39
40	.2188	.0054	.0070	.0031	.0039	.0048		40

*U. S. Standard Gage is officially a weight gage (in ounces per sq. ft.) based on wrought iron at 480 lb. per cu. ft. The values tabulated above give the thickness of steel (at 489.6 lb. per cu. ft.) that will approximate the respective weights. The other gages are officially thickness gages.
Plates—Over 6″ to 48″ wide, ¼″ and thicker; over 48″ wide, $\frac{3}{16}$″ and thicker.
Sheets—24″ to 48″ wide, under ¼″ thick; over 48″ wide, under $\frac{3}{16}$″ thick.
Strip—23$\frac{15}{16}$″ and narrower, under ¼″ thick.

COURTESY, "AMERICAN INSTITUTE OF STEEL CONSTRUCTION"

EXPANSION OF BODIES BY HEAT

The coefficient of linear expansion (ϵ) is the change in length, per unit of length, for a change of one degree of temperature. The coefficient of surface expansion is approximately two times the linear coefficient, and the coefficient of volume expansion, for solids, is approximately three times the linear coefficient.

A bar, free to move, will increase in length with an increase in temperature and will decrease in length with a decrease in temperature. The change in length will be $\epsilon t l$, where ϵ is the coefficient of linear expansion, t the change in temperature, and l the length. If the ends of a bar are fixed, a change in temperature (t) will cause a change in the unit stress of $E\epsilon t$, and in the total (stress of) $AE\epsilon t$, where A is the cross sectional area of the bar and E the modulus of elasticity.

The following table gives the coefficient of linear expansion for 100°, or 100 times the value indicated above.

Example: A piece of medium steel is exactly 40 feet long at 60° F. Find the length at 90° F. assuming the ends free to move.

$$\text{Change of length} = \epsilon t l = \frac{.00067 \times 30 \times 40}{100} = .00804 \text{ foot.}$$

The length at 90° F. is 40.00804 feet.

Example: A piece of medium steel is exactly 40 feet long and the ends are fixed. If the temperature increases 30° F., what is the resulting change in the unit stress?

$$\text{Change in unit stress} = E\epsilon t = \frac{29{,}000{,}000 \times .00067 \times 30}{100} = 5830 \text{ lbs. per sq. in.}$$

COEFFICIENTS OF EXPANSION FOR 100 DEGREES = 100ϵ

Substances	Linear Expansion	
	Centigrade	Fahrenheit
METALS AND ALLOYS		
Aluminum, wrought	.00231	.00128
Brass	.00188	.00104
Bronze	.00181	.00101
Copper	.00168	.00093
Iron, cast, gray	.00106	.00059
Iron, wrought	.00120	.00067
Iron, wire	.00124	.00069
Lead	.00286	.00159
Nickel	.00126	.00070
Steel, cast	.00110	.00061
Steel, hard	.00132	.00073
Steel, medium	.00120	.00067
Steel, soft	.00110	.00061
Zinc, rolled	.00311	.00173
STONE AND MASONRY		
Ashlar masonry	.00063	.00035
Brick masonry	.00055	.00031

Substances		Linear Expansion	
		Centigrade	Fahrenheit
Cement, portland		.00107	.00059
Concrete		.00143	.00079
Granite		.00084	.00047
Limestone		.00080	.00044
Marble		.00100	.00056
Plaster		.00166	.00092
Rubble masonry		.00063	.00035
Sandstone		.00110	.00061
Slate		.00104	.00058
TIMBER			
Fir	parallel to fiber	.00037	.00021
Maple		.00064	.00036
Oak		.00049	.00027
Pine		.00054	.00030
Fir	perpendicular to fiber	.0058	.0032
Maple		.0048	.0027
Oak		.0054	.0030
Pine		.0034	.0019

EXPANSION OF WATER

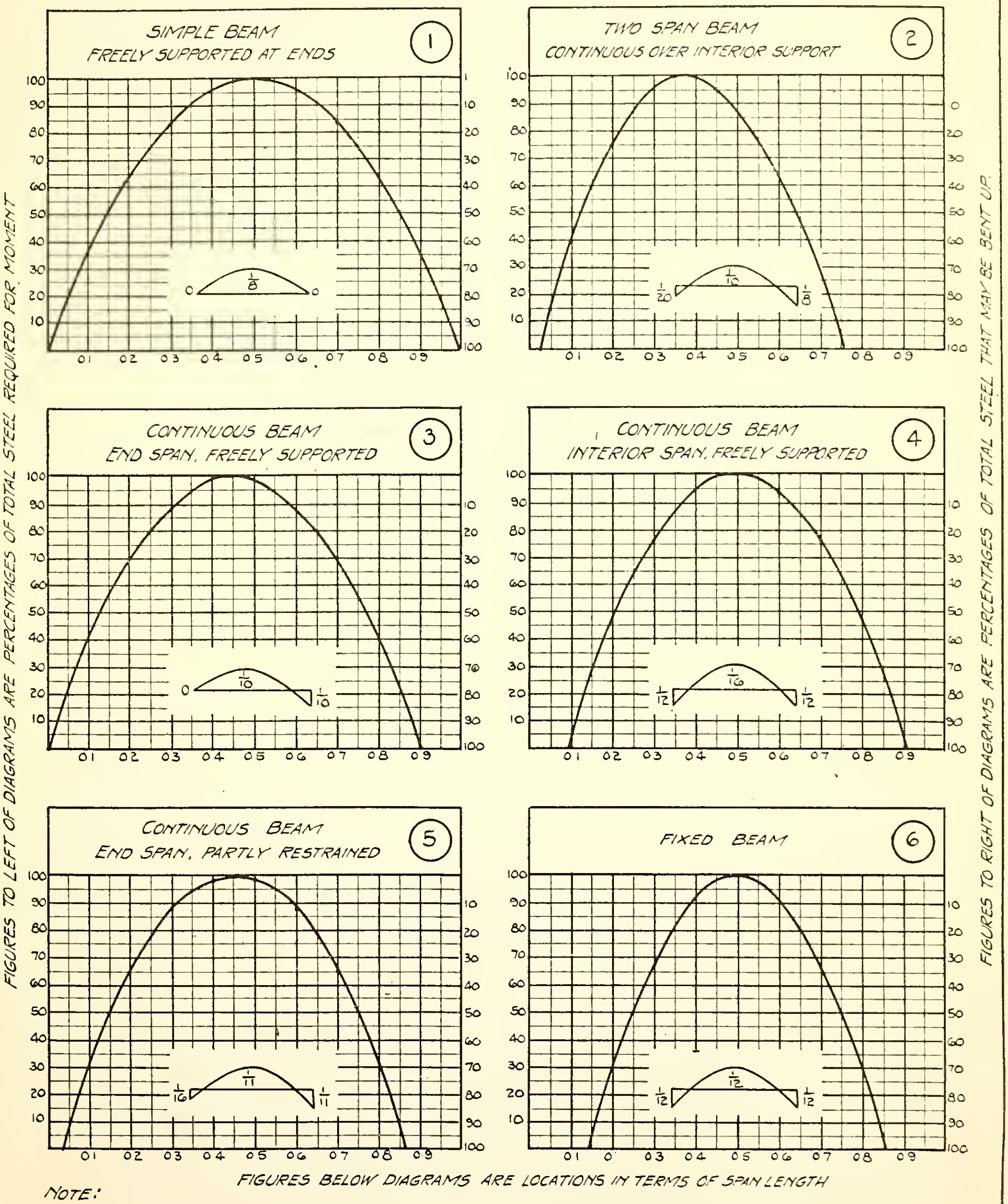
MAXIMUM DENSITY = 1

C°	Volume	C°	Volume	C°	Volume	C°	Volume	C°	Volume	C°	Volume
0	1.000126	10	1.000257	30	1.004234	50	1.011877	70	1.022384	90	1.035829
4	1.000000	20	1.001732	40	1.007627	60	1.016954	80	1.029003	100	1.043116

POINT OF BEND FOR TENSION STEEL

FOR VARIOUS TYPES OF BEAMS

UNDER UNIFORM LOAD ONLY



NOTE:

Curves show points at which bottom tension steel may be bent up for negative moment.
Point of top bend should not be less than 0.15 span for cases 1, 2, 3 and 6, wall end; nor 0.20 for others.

Part V

ALUMINUM

STRUCTURAL WELDING

WOOD

ALUMINUM AND ALUMINUM ALLOYS

The information given on aluminum alloys is primarily for review and reference purposes. The Alcoa Structural Handbook of the Aluminum Company of America should be consulted for information on all details of design and fabrication.

Commercially pure aluminum weighs 0.098 lbs. per cu. inch and, when fully annealed, has a yield strength of about 5,000 lbs. sq. in. By means of alloying and heat-treating very high yield strengths may be obtained.

The Modulus of Elasticity (E) and Modulus of Rigidity (G) for some of the common alloys are:

	E *lbs. sq. in.*	G *lbs. sq. in.*
3S, 53S, 61S	10,000,000	3,800,000
A51S, 52S	10,200,000	3,850,000
17S	10,400,000	3,900,000
14S, 24S	10,600,000	4,000,000

Because of the appreciably lower Modulus of Elasticity of Aluminum Alloys as compared with steel, it should be emphasized that the greatest practicable depth of aluminum beams should be secured where deflection must be considered. Change in length due to thermal expansion should be considered; the coefficient varies from 0.0000114 to 0.0000128 inch per inch per degree Fahrenheit. Secondary stresses induced by such temperature changes are usually less than in comparable steel structures, because of the lower modulus of elasticity.

TENSION

The tensile yield strengths, as well as the ultimate values, are given in the table accompanying. The allowable tensile working stress may be computed separately for yield and ultimate values; the lower of the two is then generally used. Good practice would seem to recommend a factor of safety of 2 for yield strength, or 3 for ultimate strength.

COMPRESSION

Compression formulae for the various aluminum alloys are expressed in terms of $\frac{KL}{r}$, where the factor K represents the effect of the end conditions of restraint of the member. The following values of K are recommended:

Both ends completely fixed	K = 0.5
One end fixed; one end pinned	K = 0.7
Both ends pinned	K = 1.0
One end fixed; one end free (Cantilever Compression Member)	K = 2.0

Most compression members in framed structures have partially fixed ends (See Singleton, *Manual of Moment Design*) so that a K value between fixed and free ends should normally be used. Generally 0.875; seldom less than 0.75.

Ultimate strength formulae for axially loaded aluminum alloy columns are given in the accompanying table.

BENDING

The basic allowable compressive working stress used in the design of beams and girders can be used only where the unsupported length of the compression flange is relatively short. To facilitate design, a torsion factor, J, is included in the tables giving elements of sections. The allowable compressive working stress on longer unsupported compression flanges must be reduced, in order to provide a suitable factor of safety against side-wise buckling failure; the equivalent radius of gyration, E_R, of the compression flange is determined in accordance with the following formula:

$$E_R = \sqrt{\frac{0.2}{S_c}\sqrt{I_1\,[J(KL)^2 + 13.1\,I_F d^2]}}$$

where E_R = Equivalent radius of gyration, compression flange.

S_c = Section modulus for beam about axis normal to web (compression side) in inches^3.

I_1 = Moment of Inertia for beam about principal axis, parallel to web, in inches^4.

L = Laterally unsupported length, compression flange, in inches.

K = Factor representing end conditions, laterally unsupported length, same as for columns.

I_F = Moment of Inertia, compressionflange, about axis parallel to web (may be assumed equal to half I_1 for symmetrical I-shaped members) in inches^4.

d = Depth of beam, inches.

J = Torsion Factor, in inches^4.

The value of J for single-web built up members is the sum of the individual tension factors for the separate rectangles as follows:

$$J = \Sigma \tfrac{1}{3} bt^3$$

where b = length and t = thickness of each rectangle, expressed in inches.

SHEAR VALUES

The yield and ultimate shear strength values are tabulated. Suitable factors of safety, in line with recommendations under "Tension" should be used. It is common practice to apply shear working stress to gross section of members, but shear on the net section should usually be investigated, also.

RIVETS

Both aluminum alloy and steel rivets are used in aluminum alloy fabrication.

Cold driving is used for 53S, T61 and A17S-T alloy rivets, and for 17S and 24S alloy rivets where proper heat-treating equipment is available. Hot driving is often desirable for rivets over ½ inch in diameter. See publications, Alcoa.

The following gives Average Ultimate Shear Strength of Driven Rivets:

A17S-T — Driven cold, as received	33,000
17S-T — Driven cold, immediately after quench	34,000
17S-T — Driven at 930°F to 950°F.	33,000
24S-T — Driven cold, immediately after quench	42,000
53S-T61 — Driven cold, as received	23,000
53S-W — Driven at 960°F. to 1050°F.	18,000
Steel — Driven cold or hot	45,000

GENERAL

The selection of an alloy to meet a specific structural application depends not only upon strength, durability and economic requirements but upon availability. Before specifying definite aluminum alloys it is suggested that the designer consult with the nearest sales office of Aluminum Company of America.

ALUMINUM ALLOYS

COURTESY, ALUMINUM COMPANY OF AMERICA

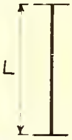
TYPICAL MECHANICAL PROPERTIES, WROUGHT ALUMINUM ALLOYS

ALLOY	TENSION			COMP.	HARDNESS	SHEAR		FATIGUE	WEIGHT
	YIELD STRENGTH (Set 0.2%)	ULTIMATE STRENGTH	ELONGATION % in 2 in.	YIELD STRENGTH (Set 0.2%)	BRINELL 500 Kg 10 mm. ball	YIELD STRENGTH (Set 0.2%)	ULTIMATE STRENGTH	ENDURANCE LIMIT	LB./CU. IN.
3S-O	6000	16000	40	6000	28	4000	11000	7000	0.099
3S-¼H	15000	18000	20	15000	35	10000	12000	8000	0.099
3S-½H	18000	21000	16	18000	40	12000	14000	9000	0.099
3S-¾H	21000	25000	14	21000	47	13000	15000	9500	0.099
4S-O	10000	26000	25	10000	45	6000	16000	14000	0.098
4S-¼H	22000	31000	17	22000	52	12000	17000	14500	0.098
4S-½H	27000	34000	12	27000	63	14000	18000	15000	0.098
4S-¾H	31000	37000	9	31000	70	17000	20000	15500	0.098
14S-T	58000	68000	13	58000	130	36000	42000	18000	0.101
17S-T	37000	60000	22	37000	105	22000	36000	18000	0.101
24S-T	46000	68000	22	46000	120	28000	41000	18000	0.101
27S-T	50000	65000	11	50000	115	30000	39000	13000	0.101
A51S-T	40000	47000	20	40000	95	26000	32000	11000	0.097
52S-O	14000	29000	30	14000	45	9000	18000	17000	0.096
52S-¼H	26000	34000	18	26000	62	15000	20000	17500	0.096
52S-½H	29000	37000	14	29000	67	16000	21000	18000	0.096
52S-¾H	34000	39000	10	34000	74	19000	23000	18500	0.096
53S-O	7000	16000	35	7000	26	5000	11000	8000	0.097
53S-W	20000	33000	30	20000	65	12000	20000	13000	0.097
53S-T	33000	39000	20	33000	80	20000	24000	13000	0.097
61S-O	8000	18000	30	8000	30	6000	12500	9000	0.098
61S-W	21000	35000	25	21000	65	14000	24000	13500	0.098
61S-T	39000	45000	15	39000	95	26000	30000	13500	0.098

$\frac{P}{A}$ = Ultimate Strength, #/□″
L = Unsupported length, inches
r = Corresponding radius gyr.
K = 0.5 for both ends fixed; K = 1.0 for both ends hinged.

ULTIMATE STRENGTH FORMULAE

AXIALLY LOADED ALUMINUM ALLOY COLUMNS



ALLOY	TYPICAL COMP. YIELD STRENGTH	$\frac{P}{A}$ For $\frac{KL}{r}$ less than C	C	$\frac{P}{A}$ For $\frac{KL}{r}$ above C	ALLOY	TYPICAL COMP. YIELD STRENGTH	$\frac{P}{A}$ For $\frac{KL}{r}$ less than C	C	$\frac{P}{A}$ For $\frac{KL}{r}$ above C	ALLOY	TYPICAL COMP. YIELD STRENGTH	$\frac{P}{A}$ For $\frac{KL}{r}$ less than C	C	$\frac{P}{A}$ For $\frac{KL}{r}$ above C
3S-O	6000	$6200 - 18\frac{KL}{r}$	194	$\frac{102{,}000{,}000}{\left(\frac{KL}{r}\right)^2}$	4S-¾H	31000	$35800 - 258\frac{KL}{r}$	92	$\frac{102{,}000{,}000}{\left(\frac{KL}{r}\right)^2}$	52S-½H	29000	$33200 - 230\frac{KL}{r}$	96	$\frac{102{,}000{,}000}{\left(\frac{KL}{r}\right)^2}$
3S-¼H	15000	$16100 - 78\frac{KL}{r}$	138	"	14S-T	58000	$74800 - 780\frac{KL}{r}$	64	"	52S-¾H	34000	$39800 - 302\frac{KL}{r}$	88	"
3S-½H	18000	$19600 - 105\frac{KL}{r}$	125	"	17S-T	37000	$43800 - 350\frac{KL}{r}$	83	"	53S-W	20000	$22000 - 124\frac{KL}{r}$	118	"
3S-¾H	21000	$23200 - 135\frac{KL}{r}$	115	"	24S-T	46000	$56600 - 510\frac{KL}{r}$	73	"	53S-T	33000	$38400 - 287\frac{KL}{r}$	90	"
4S-O	10000	$10500 - 41\frac{KL}{r}$	170	"	27S-T	50000	$62500 - 596\frac{KL}{r}$	70	"	61S-W	21000	$23200 - 135\frac{KL}{r}$	115	"
4S-¼H	22000	$24400 - 145\frac{KL}{r}$	112	"	52S-O	14000	$15000 - 70\frac{KL}{r}$	143	"	61S-T	39000	$46600 - 384\frac{KL}{r}$	81	"
4S-½H	27000	$30600 - 204\frac{KL}{r}$	100	"	52S-¼H	26000	$29400 - 192\frac{KL}{r}$	102	"					

BEARING STRENGTHS

ALUMINUM ALLOY PLATES AND SHAPES

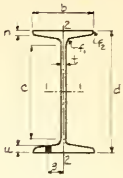
ALLOY	BEARING YIELD STRENGTH	BEARING ULTIMATE STRENGTH	ALLOY	BEARING YIELD STRENGTH	BEARING ULTIMATE STRENGTH	ALLOY	BEARING YIELD STRENGTH	BEARING ULTIMATE STRENGTH	ALLOY	BEARING YIELD STRENGTH	BEARING ULTIMATE STRENGTH
3S-O	15000	34000	4S-½H	43000	71000	52S-O	30000	61000	53S-T	53000	82000
3S-¼H	24000	36000	4S-¾H	50000	78000	52S-¼H	42000	71000	61S-O	19000	38000
3S-½H	29000	38000	14S-T	93000	129000	52S-½H	47000	78000	61S-W	34000	73000
3S-¾H	33000	42000	17S-T	59000	114000	52S-¾H	54000	82000	61S-T	62000	94000
4S-O	23000	54000	24S-T	74000	129000	53S-O	17000	34000			
4S-¼H	35000	65000	27S-T	80000	123000	53S-W	32000	69000			

ALUMINUM STANDARD BEAMS

ELEMENTS OF SECTIONS

J = Torsion Factor, in.⁴

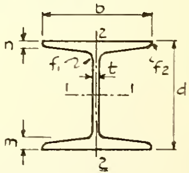
COURTESY, ALUMINUM COMPANY OF AMERICA



DEPTH	WEIGHT PER FT.	AREA SQ. IN.	Dimensions							Axis 1-1			Axis 2-2			Rivet			J	Tools
			d	b	t	n	f₁	f₂	c	I	S	r	I	S	r	DIAM.	g	u		
3	2.02	1.67	3	2.330	.170	.170	0.27	0.10	1¾	2.52	1.68	1.23	0.46	0.39	0.52	⅜	¾	5/16	0.045	851-A
	2.31	1.91	3	2.411	.251	.170	0.27	0.10	1¾	2.71	1.80	1.19	0.51	0.42	0.52	⅜	¾	5/16	0.061	851-J
	2.67	2.21	3	2.509	.349	.170	0.27	0.10	1¾	2.93	1.95	1.15	0.59	0.47	0.52	⅜	¾	5/16	0.093	851-D
4	2.72	2.25	4	2.660	.190	.190	0.29	0.11	2¾	6.06	3.03	1.64	0.76	0.57	0.58	½	¾	5/16	0.074	851-D
	3.03	2.50	4	2.723	.253	.190	0.29	0.11	2¾	6.40	3.20	1.60	0.82	0.61	0.57	½	¾	5/16	0.092	
	3.38	2.79	4	2.796	.326	.190	0.29	0.11	2¾	6.79	3.39	1.56	0.90	0.65	0.57	½	¾	5/16	0.120	851-F
	3.74	3.09	4	2.870	.400	.190	0.29	0.11	2¾	7.18	3.59	1.52	0.99	0.69	0.57	½	¾	5/16	0.170	
5	3.53	2.92	5	3.000	.210	.210	0.31	0.13	3½	12.26	4.90	2.05	1.21	0.81	0.64	½	⅞	⅜	0.12	851-C
	4.36	3.60	5	3.137	.347	.210	0.31	0.13	3½	13.69	5.48	1.95	1.41	0.90	0.63	½	⅞	⅜	0.19	851-E
	5.25	4.34	5	3.284	.494	.210	0.31	0.13	3½	15.22	6.09	1.87	1.66	1.01	0.62	½	⅞	⅜	0.33	851-O
6	4.43	3.66	6	3.330	.230	.230	0.33	0.14	4½	22.08	7.36	2.46	1.82	1.09	0.71	⅝	1	⅜	0.17	851-K
	5.25	4.34	6	3.443	.343	.230	0.33	0.14	4½	24.11	8.04	2.36	2.04	1.19	0.69	⅝	1	⅜	0.24	851-L
	6.13	5.07	6	3.565	.465	.230	0.33	0.14	4½	26.31	8.77	2.28	2.31	1.30	0.68	⅝	1	⅜	0.38	
7	5.42	4.48	7	3.660	.250	.250	0.35	0.15	5¼	36.69	10.48	2.86	2.63	1.44	0.77	⅝	1⅛	⅜	0.25	
	6.23	5.15	7	3.755	.345	.250	0.35	0.15	5¼	39.40	11.26	2.77	2.88	1.53	0.75	⅝	1⅛	⅜	0.32	851-H
	7.12	5.88	7	3.860	.450	.250	0.35	0.15	5¼	42.40	12.12	2.69	3.17	1.64	0.73	⅝	1⅛	⅜	0.46	
8	6.53	5.40	8	4.000	.270	.270	0.37	0.16	6¼	57.55	14.39	3.27	3.73	1.86	0.83	¾	1⅛	7/16	0.34	851-G
	7.30	6.03	8	4.079	.349	.270	0.37	0.16	6¼	60.92	15.23	3.18	3.99	1.95	0.81	¾	1⅛	7/16	0.42	
	8.19	6.77	8	4.171	.441	.270	0.37	0.16	6¼	64.85	16.21	3.10	4.31	2.07	0.80	¾	1⅛	7/16	0.56	
	9.07	7.49	8	4.262	.532	.270	0.37	0.16	6¼	68.73	17.18	3.03	4.66	2.19	0.79	¾	1⅛	7/16	0.75	
9	7.72	6.38	9	4.330	.290	.290	0.39	0.17	7	85.90	19.09	3.67	5.09	2.35	0.89	¾	1¼	½	0.46	
	8.89	7.35	9	4.437	.397	.290	0.39	0.17	7	92.40	20.53	3.55	5.54	2.50	0.87	¾	1¼	½	0.61	
	10.68	8.82	9	4.601	.561	.290	0.39	0.17	7	102.36	22.75	3.41	6.30	2.74	0.85	¾	1¼	½	0.99	
10	9.01	7.45	10	4.660	.310	.310	0.41	0.19	8	123.39	24.68	4.07	6.78	2.91	0.95	¾	1⅜	½	0.62	851-P
	10.67	8.82	10	4.797	.447	.310	0.41	0.19	8	134.81	26.96	3.91	7.50	3.13	0.92	¾	1⅜	½	0.86	
	12.45	10.29	10	4.944	.594	.310	0.41	0.19	8	147.06	29.41	3.78	8.36	3.38	0.90	¾	1⅜	½	1.31	
12	11.31	9.35	12	5.000	.350	.350	0.45	0.21	9¾	218.13	36.35	4.83	9.35	3.74	1.00	¾	1½	9/16	0.92	
	12.44	10.28	12	5.078	.428	.350	0.45	0.21	9¾	229.36	38.23	4.72	9.87	3.89	0.98	¾	1½	9/16	1.10	
	14.49	11.97	12	5.250	.460	.460	0.56	0.28	9¼	272.15	45.36	4.77	13.54	5.16	1.06	¾	1½	¾	1.78	
	16.01	13.23	12	5.355	.565	.460	0.56	0.28	9¼	287.27	47.88	4.66	14.50	5.42	1.05	¾	1½	¾	2.19	
	17.78	14.70	12	5.477	.687	.460	0.56	0.28	9¼	304.84	50.81	4.56	15.71	5.74	1.03	¾	1¾	¾	2.85	

ALUMINUM H-BEAMS

ELEMENTS OF SECTIONS



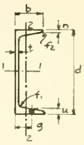
DEPTH	WEIGHT PER FT.	AREA SQ. IN.	Dimensions							Axis 1-1			Axis 2-2			J	Tools
			d	b	t	m	n	f₁	f₂	I	S	r	I	S	r		
4	4.85	4.00	4	4.0	.313	.453	.290	.313	.145	10.72	5.36	1.64	3.56	1.78	0.94	0.22	3002-A
5	6.63	5.48	5	5.0	.313	.503	.330	.313	.165	23.82	9.53	2.08	7.82	3.13	1.19	0.34	3002-B
6	8.04	6.64	6	5.938	.250	.542	.360	.313	.180	44.06	14.69	2.58	14.18	4.77	1.46	0.45	3002-C
	8.49	7.02	6	6.0	.313	.542	.360	.313	.180	45.19	15.06	2.54	14.65	4.88	1.44	0.50	
	9.40	7.77	6	6.125	.438	.542	.360	.313	.180	47.44	15.81	2.47	15.65	5.11	1.42	0.62	
8	11.51	9.52	8	7.938	.313	.560	.358	.313	.179	112.94	28.23	3.45	34.15	8.60	1.89	0.68	3002-D
	12.11	10.01	8	8.0	.375	.560	.358	.313	.179	115.58	28.90	3.40	35.01	8.75	1.87	0.75	
	13.32	11.01	8	8.125	.500	.560	.358	.313	.179	120.92	30.23	3.31	36.79	9.06	1.83	0.96	3002-E

ALUMINUM STANDARD CHANNELS

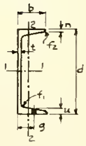
ELEMENTS OF SECTIONS

J = Torsion Factor, in.⁴

COURTESY, ALUMINUM COMPANY OF AMERICA



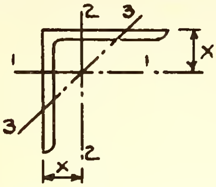
DEPTH	WEIGHT PER FT.	AREA SQ. IN.	Dimensions							Axis 1-1			Axis 2-2				Rivet			J	Tools
			d	b	t	n	f_1	f_2	c	I	S	r	I	S	r	x	DIA.	g	u		
3	1.46	1.21	3	1.410	.170	.170	.27	.10	1¾	1.66	1.10	1.17	0.20	0.20	0.40	0.44	½	⅞	¼	0.031	Roll
	1.52	1.26	3	1.427	.187	.170	.27	.10	1¾	1.69	1.13	1.16	0.21	0.21	0.41	0.44	½	⅞	¼	0.033	"
	1.78	1.47	3	1.498	.258	.170	.27	.10	1¾	1.85	1.24	1.12	0.25	0.23	0.41	0.44	½	⅞	¼	0.047	"
	2.00	1.66	3	1.560	.320	.170	.27	.10	1¾	1.99	1.33	1.10	0.28	0.25	0.41	0.45	½	⅞	¼	0.066	"
	2.13	1.76	3	1.596	.356	.170	.27	.10	1¾	2.07	1.38	1.08	0.31	0.27	0.42	0.46	½	⅞	¼	0.080	"
4	1.90	1.57	4	1.580	.180	.180	.28	.11	2¾	3.83	1.92	1.56	0.32	0.28	0.45	0.46	½	1	5/16	0.045	Roll
	2.22	1.84	4	1.647	.247	.180	.28	.11	2¾	4.19	2.10	1.51	0.37	0.31	0.45	0.45	½	1	5/16	0.062	"
	2.58	2.13	4	1.720	.320	.180	.28	.11	2¾	4.58	2.29	1.47	0.43	0.34	0.45	0.46	½	1	5/16	0.090	"
5	2.38	1.97	5	1.75	.190	.190	.29	.11	3¾	7.49	3.00	1.95	0.48	0.38	0.49	0.48	½	1⅛	5/16	0.064	Rolls
	2.59	2.14	5	1.785	.225	.190	.29	.11	3¾	7.86	3.14	1.91	0.52	0.40	0.49	0.48	½	1⅛	5/16	0.074	"
	3.20	2.64	5	1.885	.325	.190	.29	.11	3¾	8.90	3.56	1.83	0.63	0.45	0.49	0.48	½	1⅛	5/16	0.12	"
	4.09	3.38	5	2.032	.472	.190	.29	.11	3¾	10.43	4.17	1.76	0.81	0.53	0.49	0.51	½	1⅛	5/16	0.25	
6	2.91	2.40	6	1.920	.200	.200	.30	.12	4½	13.12	4.37	2.34	0.69	0.49	0.54	0.51	⅝	1⅛	5/16	0.088	852-F
	3.09	2.55	6	1.945	.225	.200	.30	.12	4½	13.57	4.52	2.31	0.73	0.51	0.54	0.51	⅝	1⅛	5/16	0.097	Rolls
	3.73	3.09	6	2.034	.314	.200	.30	.12	4½	15.18	5.06	2.22	0.87	0.56	0.53	0.50	⅝	1⅛	⅜	0.14	"
	4.63	3.82	6	2.157	.437	.200	.30	.12	4½	17.39	5.80	2.13	1.05	0.64	0.52	0.51	⅝	1⅜	⅜	0.26	"
7	3.47	2.87	7	2.090	.210	.210	.31	.13	5½	21.27	6.08	2.72	0.97	0.63	0.58	0.54	⅝	1¼	⅜	0.12	
	3.64	3.01	7	2.110	.230	.210	.31	.13	5½	21.84	6.24	2.69	1.01	0.64	0.58	0.54	⅝	1¼	7/16	0.13	Roll
	4.36	3.60	7	2.194	.314	.210	.31	.13	5½	24.24	6.93	2.60	1.17	0.70	0.57	0.52	⅝	1¼	⅜	0.18	"
	5.24	4.33	7	2.299	.419	.210	.31	.13	5½	27.24	7.78	2.51	1.38	0.78	0.56	0.53	⅝	1¼	7/16	0.29	"
	6.13	5.07	7	2.404	.524	.210	.31	.13	5½	30.25	8.64	2.44	1.59	0.86	0.56	0.55	⅝	1½	7/16	0.47	852-Q
8	4.38	3.62	8	2.290	.250	.220	.32	.13	6¼	33.85	8.46	3.06	1.40	0.81	0.62	0.56	¾	1⅜	⅜	0.17	Roll
	4.89	4.04	8	2.343	.303	.220	.32	.13	6¼	36.11	9.03	2.99	1.53	0.85	0.61	0.55	¾	1⅜	⅜	0.21	"
	5.78	4.78	8	2.435	.395	.220	.32	.13	6¼	40.04	10.01	2.90	1.75	0.93	0.61	0.55	¾	1½	7/16	0.32	"
	6.67	5.51	8	2.527	.487	.220	.32	.13	6¼	43.96	10.99	2.82	1.98	1.01	0.60	0.57	¾	1½	7/16	0.47	"
	6.99	5.78	8	2.560	.520	.220	.32	.13	6¼	45.37	11.34	2.80	2.07	1.04	0.60	0.57	¾	1½	7/16	0.55	"
9	4.74	3.91	9	2.430	.230	.230	.33	.14	7¼	47.68	10.60	3.49	1.75	0.96	0.67	0.60	¾	1⅜	7/16	0.20	852-R
	5.34	4.41	9	2.485	.285	.230	.33	.14	7¼	51.02	11.34	3.40	1.93	1.01	0.66	0.59	¾	1⅜	7/16	0.24	
	7.11	5.88	9	2.648	.448	.230	.33	.14	7¼	60.92	13.54	3.22	2.42	1.17	0.64	0.58	¾	1½	½	0.47	852-T
	8.90	7.35	9	2.812	.612	.230	.33	.14	7¼	70.89	15.75	3.11	2.94	1.34	0.63	0.61	¾	1½	½	0.92	852-U
10	5.43	4.49	10	2.600	.240	.240	.34	.14	8¼	67.37	13.47	3.87	2.28	1.16	0.71	0.63	¾	1½	7/16	0.25	852-P
	7.11	5.88	10	2.739	.379	.240	.34	.14	8¼	78.95	15.79	3.66	2.81	1.32	0.69	0.61	¾	1½	7/16	0.41	
	8.89	7.35	10	2.886	.526	.240	.34	.14	8¼	91.20	18.24	3.52	3.36	1.48	0.68	0.62	¾	1¾	½	0.75	
	10.67	8.82	10	3.033	.673	.240	.34	.14	8¼	103.45	20.69	3.43	3.95	1.66	0.67	0.65	¾	1¾	½	1.32	
12	7.63	6.30	12	2.960	.300	.280	.38	.17	10	131.84	21.97	4.57	3.99	1.76	0.80	0.69	⅞	1¾	½	0.46	Roll
	8.89	7.35	12	3.047	.387	.280	.38	.17	10	144.37	24.06	4.43	4.47	1.89	0.78	0.67	⅞	1¾	½	0.61	"
	10.67	8.82	12	3.170	.510	.280	.38	.17	10	162.08	27.01	4.29	5.14	2.06	0.76	0.67	⅞	1¾	½	0.95	"
	12.45	10.29	12	3.292	.632	.280	.38	.17	10	179.65	29.94	4.18	5.82	2.24	0.75	0.69	⅞	2	⅝	1.48	"



ALUMINUM SPECIAL CHANNELS

ELEMENTS OF SECTIONS

DEPTH	WEIGHT PER FT.	AREA SQ. IN.	Dimensions								Axis 1-1			Axis 2-2				J	Tools
			d	b	t	SLOPE	n	f_1	f_2	c	I	S	r	I	S	r	x		
3	2.30	1.90	3	2.000	.250	1:12.1	.250	.250	0	1¾	2.61	1.74	1.17	0.68	0.52	0.60	0.68	0.068	5287
	2.78	2.30	3	2.000	.375	0	.375	.188	.375	1¾	2.89	1.92	1.12	0.78	0.59	0.58	0.67	0.12	2229
4	3.41	2.82	4	2.500	.318	1:34.9	.313	.375	.125	2⅜	6.84	3.42	1.56	1.62	0.95	0.76	0.81	0.50	4885
5	3.19	2.64	5	2.875	.188	1:10.7	.188	.250	0.94	3½	11.20	4.48	2.06	1.91	0.96	0.85	0.89	0.18	1351
	4.88	4.03	5	2.500	.500	0	.375	.375	.250	3½	13.37	5.35	1.82	1.94	1.08	0.69	0.71	0.30	1665
	5.99	4.95	5	2.875	.438	1:9.8	.438	.250	.094	3	18.13	7.25	1.91	3.57	1.87	0.85	0.96	0.55	1052
6	5.94	4.91	6	3.000	.500	0	.375	.375	.250	4½	24.05	8.02	2.21	3.52	1.61	0.85	0.81	0.36	1666
	6.10	5.04	6	3.500	.375	1:49.6	.412	.480	.420	4	28.22	9.41	2.37	5.58	2.31	1.05	1.09	0.32	2658
8	6.62	5.47	8	3.000	.380	1:14.4	.380	.550	.200	5¾	50.44	12.61	3.04	3.49	1.56	0.80	0.76	0.38	11866
	8.09	6.68	8	3.500	.425	1:28.5	.471	.525	.375	5¾	63.76	15.94	3.09	7.06	2.84	1.03	1.01	0.56	10005
10	8.84	7.30	10	3.500	.375	1:9	.375	.625	.188	7½	109.62	21.92	3.88	7.19	2.80	0.99	0.93	0.66	Rolls
	9.59	7.93	10	3.563	.438	1:9	.375	.625	.188	7½	114.87	22.97	3.81	7.73	2.93	0.99	0.92	0.78	"
	10.34	8.55	10	3.625	.500	1:9	.375	.625	.188	7½	120.03	24.01	3.75	8.25	3.04	0.98	0.91	0.94	"

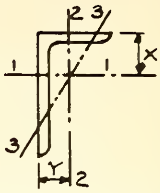


ALUMINUM ANGLES

ELEMENTS OF SECTIONS

COURTESY, ALUMINUM COMPANY OF AMERICA

J = Torsion Factor, in.^{4}



SIZE	THICKNESS	WEIGHT PER FT.	AREA SQ. IN.	Axis 1-1				Axis 2-2				Axis 3-3	J
				I	S	r	x	I	S	r	y	r	
6x6	3/8	5.27	4.35	14.85	3.38	1.85	1.60	14.85	3.38	1.85	1.60	1.18	.211
	7/16	6.11	5.05	17.15	3.93	1.84	1.63	17.15	3.93	1.84	1.63	1.18	.335
	1/2	6.95	5.74	19.38	4.46	1.84	1.66	19.38	4.46	1.84	1.66	1.17	.500
	9/16	7.78	6.43	21.54	4.99	1.83	1.68	21.54	4.99	1.83	1.68	1.17	.712
	5/8	8.59	7.10	23.64	5.51	1.82	1.71	23.64	5.51	1.82	1.71	1.17	.977
	11/16	9.40	7.77	25.67	6.02	1.82	1.73	25.67	6.02	1.82	1.73	1.17	1.30
	3/4	10.20	8.43	27.64	6.52	1.81	1.76	27.64	6.52	1.81	1.76	1.16	1.69
6x4	3/8	4.36	3.60	13.02	3.17	1.90	1.90	4.63	1.50	1.13	0.91	0.86	.176
	7/16	5.05	4.18	15.02	3.69	1.90	1.93	5.34	1.74	1.13	0.94	0.86	.279
	1/2	5.74	4.74	16.95	4.19	1.89	1.96	6.01	1.98	1.13	0.97	0.86	.417
	9/16	6.42	5.30	18.82	4.69	1.88	1.98	6.65	2.21	1.12	0.99	0.85	.593
	5/8	7.08	5.85	20.63	5.17	1.88	2.01	7.27	2.44	1.11	1.02	0.85	.814
	11/16	7.74	6.40	22.39	5.64	1.87	2.03	7.86	2.66	1.11	1.04	0.85	1.08
	3/4	8.39	6.93	24.08	6.11	1.86	2.06	8.43	2.87	1.10	1.07	0.85	1.41
6x3½	5/16	3.49	2.88	10.64	2.64	1.92	1.97	2.70	0.98	0.97	0.74	0.76	.097
	3/8	4.15	3.43	12.60	3.15	1.92	2.00	3.19	1.17	0.96	0.77	0.75	.167
	7/16	4.81	3.98	14.50	3.65	1.91	2.03	3.66	1.35	0.96	0.80	0.75	.265
	1/2	5.46	4.51	16.34	4.14	1.90	2.06	4.11	1.53	0.95	0.82	0.75	.396
	9/16	6.10	5.04	18.11	4.62	1.90	2.08	4.53	1.71	0.95	0.85	0.75	.564
	5/8	6.73	5.56	19.83	5.09	1.89	2.11	4.94	1.88	0.94	0.87	0.74	.773
	11/16	7.35	6.07	21.49	5.56	1.88	2.13	5.33	2.05	0.94	0.89	0.74	1.03
	3/4	7.95	6.57	23.09	6.01	1.87	2.16	5.71	2.21	0.93	0.92	0.74	1.34
5x5	3/8	4.36	3.60	8.37	2.30	1.52	1.36	8.37	2.30	1.52	1.36	0.98	.176
	7/16	5.05	4.18	9.65	2.67	1.52	1.38	9.65	2.67	1.52	1.38	0.97	.279
	1/2	5.74	4.74	10.89	3.03	1.52	1.41	10.89	3.03	1.52	1.41	0.97	.417
	9/16	6.42	5.30	12.08	3.39	1.51	1.43	12.08	3.39	1.51	1.43	0.97	.593
	5/8	7.08	5.85	13.22	3.73	1.50	1.46	13.22	3.73	1.50	1.46	0.97	.814
	11/16	7.74	6.40	14.33	4.07	1.50	1.48	14.33	4.07	1.50	1.48	0.97	1.08
	3/4	8.39	6.93	15.39	4.41	1.49	1.51	15.39	4.41	1.49	1.51	0.96	1.41
5x3½	5/16	3.09	2.56	6.39	1.85	1.58	1.55	2.58	0.96	1.00	0.81	0.75	.086
	3/8	3.69	3.05	7.56	2.21	1.58	1.58	3.04	1.15	1.00	0.84	0.75	.149
	7/16	4.27	3.53	8.69	2.56	1.57	1.61	3.49	1.33	0.99	0.87	0.75	.237
	1/2	4.84	4.00	9.77	2.90	1.56	1.63	3.91	1.50	0.99	0.89	0.74	.354
	9/16	5.40	4.46	10.82	3.24	1.56	1.66	4.32	1.67	0.98	0.92	0.74	.504
	5/8	5.95	4.92	11.82	3.56	1.55	1.68	4.70	1.84	0.98	0.94	0.74	.692
5x3x3/8		3.45	2.85	7.15	2.15	1.59	1.68	1.93	0.84	0.82	0.69	0.64	.141
4x4	1/4	2.35	1.94	2.94	1.00	1.23	1.07	2.94	1.00	1.23	1.07	0.79	.042
	5/16	2.91	2.41	3.61	1.24	1.23	1.10	3.61	1.24	1.23	1.10	0.78	.081
	3/8	3.46	2.86	4.26	1.48	1.22	1.12	4.26	1.48	1.22	1.12	0.78	.141
	7/16	4.01	3.31	4.87	1.71	1.21	1.15	4.87	1.71	1.21	1.15	0.78	.223
	1/2	4.54	3.75	5.46	1.93	1.21	1.17	5.46	1.93	1.21	1.17	0.78	.333
	9/16	5.07	4.19	6.02	2.15	1.20	1.20	6.02	2.15	1.20	1.20	0.77	.475
	5/8	5.58	4.61	6.56	2.36	1.19	1.22	6.56	2.36	1.19	1.22	0.77	.651
	11/16	6.09	5.03	7.08	2.57	1.19	1.24	7.08	2.57	1.19	1.24	0.77	.867
	3/4	6.58	5.44	7.57	2.77	1.18	1.26	7.57	2.77	1.18	1.26	0.77	1.125
4x3½	5/16	2.70	2.23	3.40	1.19	1.23	1.15	2.42	0.93	1.04	0.91	0.72	.076
	3/8	3.22	2.66	4.02	1.43	1.23	1.18	2.85	1.11	1.04	0.94	0.72	.132
	7/16	3.72	3.08	4.61	1.65	1.22	1.21	3.27	1.29	1.03	0.96	0.71	.209
	1/2	4.22	3.49	5.17	1.87	1.22	1.23	3.67	1.46	1.03	0.99	0.71	.313
4x3	1/4	2.05	1.69	2.68	0.96	1.26	1.21	1.29	0.56	0.87	0.72	0.64	.036
	5/16	2.53	2.09	3.29	1.19	1.25	1.24	1.58	0.70	0.87	0.74	0.64	.071
	3/8	3.01	2.49	3.88	1.42	1.25	1.26	1.86	0.83	0.86	0.77	0.64	.123
	7/16	3.48	2.87	4.43	1.63	1.24	1.29	2.12	0.96	0.86	0.79	0.63	.195
	1/2	3.94	3.25	4.96	1.85	1.24	1.31	2.36	1.08	0.85	0.82	0.63	.292
	9/16	4.39	3.62	5.47	2.05	1.23	1.34	2.60	1.20	0.85	0.84	0.63	.415
	5/8	4.83	3.99	5.95	2.25	1.22	1.36	2.82	1.32	0.84	0.86	0.63	.570
3½x3½	1/4	2.05	1.69	1.93	0.76	1.07	0.94	1.93	0.76	1.07	0.94	0.69	.036
	5/16	2.53	2.09	2.37	0.94	1.06	0.97	2.37	0.94	1.06	0.97	0.68	.071
	3/8	3.01	2.49	2.79	1.11	1.06	1.00	2.79	1.11	1.06	1.00	0.68	.123
	7/16	3.48	2.87	3.18	1.28	1.05	1.02	3.18	1.28	1.05	1.02	0.68	.195
	1/2	3.94	3.25	3.56	1.45	1.05	1.05	3.56	1.45	1.05	1.05	0.68	.292
	9/16	4.39	3.62	3.92	1.61	1.04	1.07	3.92	1.61	1.04	1.07	0.67	.415
	5/8	4.83	3.99	4.26	1.77	1.03	1.09	4.26	1.77	1.03	1.09	0.67	.570
3½x3	1/4	1.89	1.57	1.84	0.74	1.08	1.01	1.28	0.57	0.90	0.76	0.63	.034
	5/16	2.34	1.94	2.26	0.92	1.08	1.04	1.52	0.69	0.89	0.79	0.62	.066
	3/8	2.78	2.30	2.65	1.09	1.07	1.06	1.79	0.82	0.88	0.82	0.62	.114
	7/16	3.21	2.66	3.03	1.26	1.07	1.09	2.04	0.94	0.88	0.84	0.61	.181
	1/2	3.63	3.00	3.38	1.42	1.06	1.11	2.27	1.06	0.87	0.86	0.61	.271
3½x2½	1/4	1.73	1.43	1.73	0.72	1.10	1.09	0.73	0.38	0.71	0.60	0.53	.031
	5/16	2.14	1.77	2.12	0.89	1.09	1.12	0.89	0.48	0.71	0.62	0.53	.061
	3/8	2.55	2.10	2.49	1.06	1.09	1.14	1.05	0.57	0.71	0.65	0.53	.105
	7/16	2.94	2.43	2.84	1.22	1.08	1.17	1.19	0.65	0.70	0.67	0.53	.167
	1/2	3.32	2.74	3.17	1.37	1.08	1.19	1.32	0.73	0.69	0.70	0.53	.250
3x3	3/16	1.33	1.10	0.93	0.42	0.92	0.80	0.93	0.42	0.92	0.80	0.59	.013
	1/4	1.73	1.43	1.18	0.54	0.91	0.82	1.18	0.54	0.91	0.82	0.58	.031
	5/16	2.14	1.77	1.45	0.67	0.91	0.85	1.45	0.67	0.91	0.85	0.58	.061
	3/8	2.55	2.10	1.70	0.80	0.90	0.87	1.70	0.80	0.90	0.87	0.58	.105
	7/16	2.94	2.43	1.94	0.92	0.89	0.90	1.94	0.92	0.89	0.90	0.58	.167
	1/2	3.32	2.74	2.16	1.04	0.89	0.92	2.16	1.04	0.89	0.92	0.58	.250
	9/16	3.69	3.05	2.37	1.15	0.88	0.94	2.37	1.15	0.88	0.94	0.58	.356
	5/8	4.06	3.35	2.57	1.26	0.88	0.97	2.57	1.26	0.88	0.97	0.58	.488
3x2½	1/4	1.58	1.31	1.12	0.53	0.92	0.89	0.70	0.38	0.73	0.64	0.52	.029
	5/16	1.95	1.62	1.37	0.66	0.92	0.92	0.86	0.47	0.73	0.67	0.51	.056
	3/8	2.32	1.92	1.60	0.78	0.91	0.94	1.00	0.55	0.72	0.69	0.51	.097
	7/16	2.67	2.21	1.82	0.90	0.91	0.97	1.14	0.64	0.72	0.72	0.51	.154
	1/2	3.02	2.49	2.03	1.01	0.90	0.99	1.26	0.72	0.71	0.74	0.51	.229
3x2	3/16	1.10	0.91	0.82	0.40	0.95	0.94	0.29	0.19	0.56	0.46	0.43	.011
	1/4	1.44	1.19	1.06	0.52	0.94	0.97	0.38	0.25	0.56	0.48	0.43	.026
	5/16	1.78	1.47	1.29	0.65	0.94	1.00	0.45	0.30	0.56	0.51	0.43	.051
	3/8	2.11	1.74	1.51	0.76	0.93	1.03	0.53	0.36	0.55	0.53	0.42	.088
	7/16	2.42	2.00	1.71	0.88	0.92	1.05	0.59	0.41	0.55	0.56	0.42	.140
	1/2	2.73	2.26	1.90	0.99	0.92	1.07	0.66	0.46	0.54	0.58	0.42	.208
2½x2½	1/8	0.75	0.62	0.37	0.20	0.77	0.65	0.37	0.20	0.77	0.65	0.50	.0033
	3/16	1.10	0.91	0.54	0.30	0.77	0.68	0.54	0.30	0.77	0.68	0.49	.011
	1/4	1.45	1.19	0.69	0.39	0.76	0.71	0.69	0.39	0.76	0.71	0.49	.026
	5/16	1.78	1.47	0.84	0.48	0.76	0.73	0.84	0.48	0.76	0.73	0.49	.051
	3/8	2.11	1.74	0.98	0.56	0.75	0.76	0.98	0.56	0.75	0.76	0.48	.088
	7/16	2.42	2.00	1.10	0.64	0.74	0.78	1.10	0.64	0.74	0.78	0.48	.140
	1/2	2.73	2.26	1.22	0.72	0.73	0.80	1.22	0.72	0.73	0.80	0.48	.208
2½x2	1/8	0.67	0.55	0.34	0.19	0.79	0.72	0.20	0.13	0.60	0.48	0.43	.0029
	3/16	0.99	0.82	0.50	0.29	0.78	0.75	0.29	0.19	0.59	0.51	0.42	.010
	1/4	1.29	1.07	0.65	0.38	0.78	0.78	0.37	0.25	0.58	0.53	0.42	.023
	5/16	1.59	1.32	0.78	0.46	0.77	0.80	0.44	0.30	0.58	0.55	0.42	.046
	3/8	1.88	1.55	0.91	0.54	0.76	0.83	0.51	0.36	0.57	0.58	0.42	.079
	7/16	2.16	1.78	1.02	0.62	0.76	0.85	0.57	0.41	0.57	0.60	0.42	.126
	1/2	2.43	2.01	1.13	0.69	0.75	0.87	0.63	0.46	0.56	0.62	0.42	.188
2x2	1/8	0.59	0.49	0.18	0.13	0.61	0.53	0.18	0.13	0.61	0.53	0.40	.0026
	3/16	0.87	0.72	0.27	0.19	0.61	0.56	0.27	0.19	0.61	0.56	0.39	.0088
	1/4	1.14	0.94	0.34	0.24	0.60	0.58	0.34	0.24	0.60	0.58	0.39	.021
	5/16	1.40	1.16	0.41	0.30	0.60	0.61	0.41	0.30	0.60	0.61	0.39	.041
	3/8	1.65	1.37	0.47	0.35	0.59	0.63	0.47	0.35	0.59	0.63	0.39	.070
	7/16	1.89	1.57	0.53	0.39	0.58	0.65	0.53	0.39	0.58	0.65	0.39	.112

STRUCTURAL WELDING

A single page was devoted to this subject when the MANUAL was first published in 1933. Such great strides in the art have been made, and the use of welding has grown so rapidly since 1933 that it cannot be lightly dismissed.

The information given herein is that ordinarily used in the design office. It is not, of course, by any means all-inclusive. The *Welding Handbook* of the American Welding Society should be referred to as the basic authority. The author cannot speak too highly of *Manual of Design for Arc Welded Steel Structures* of Air Reduction Sales Company, as compiled by LaMotte Grover, through whose courtesy permission was granted for reproduction of basic information.

The "Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings (Riveted, Bolted and Arc-Welded Construction)" of the American Institute of Steel Construction, reprinted fully in this book, give weld specifications and procedure.

In some cases, an individual designer may wish to use basic stresses other than those shown in the specifications. For such conditions the following is given:

Butt Welds

For Tension, $P = (T \times 20000) \times L$
For Compression, Weld Value = Base Metal Value
For Shear, $P = (T \times 13000) \times L$

where T = Throat thickness and L = Length of weld, both in inches.

Fillet Welds

Allowable Total Stress, $P = \left(\frac{D}{1/8} \times 1200\right) \times L$

where D = Weld size expressed in units of ⅛ inch, L = Length of weld, and the allowable stress per linear inch per eighth-inch of size = 1200.

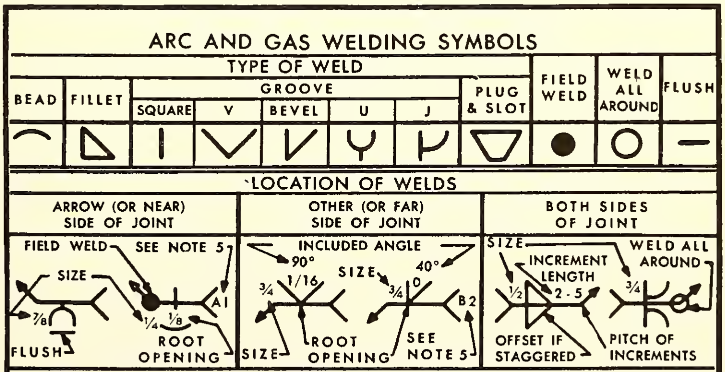
Table giving Allowable Loads on Fillet Welds, all sizes, accompanies.

Slot and Plug Welds

Diameter of hole not less than thickness of punched material plus $\frac{5}{16}$", nor more than 2¼ times thickness. Allowable shear value = 13,600 p.s.i. Length of a fillet weld in a slot or hole is the average length of throat of fillet. For a round hole this length, $L = \pi(d - T/2)$.

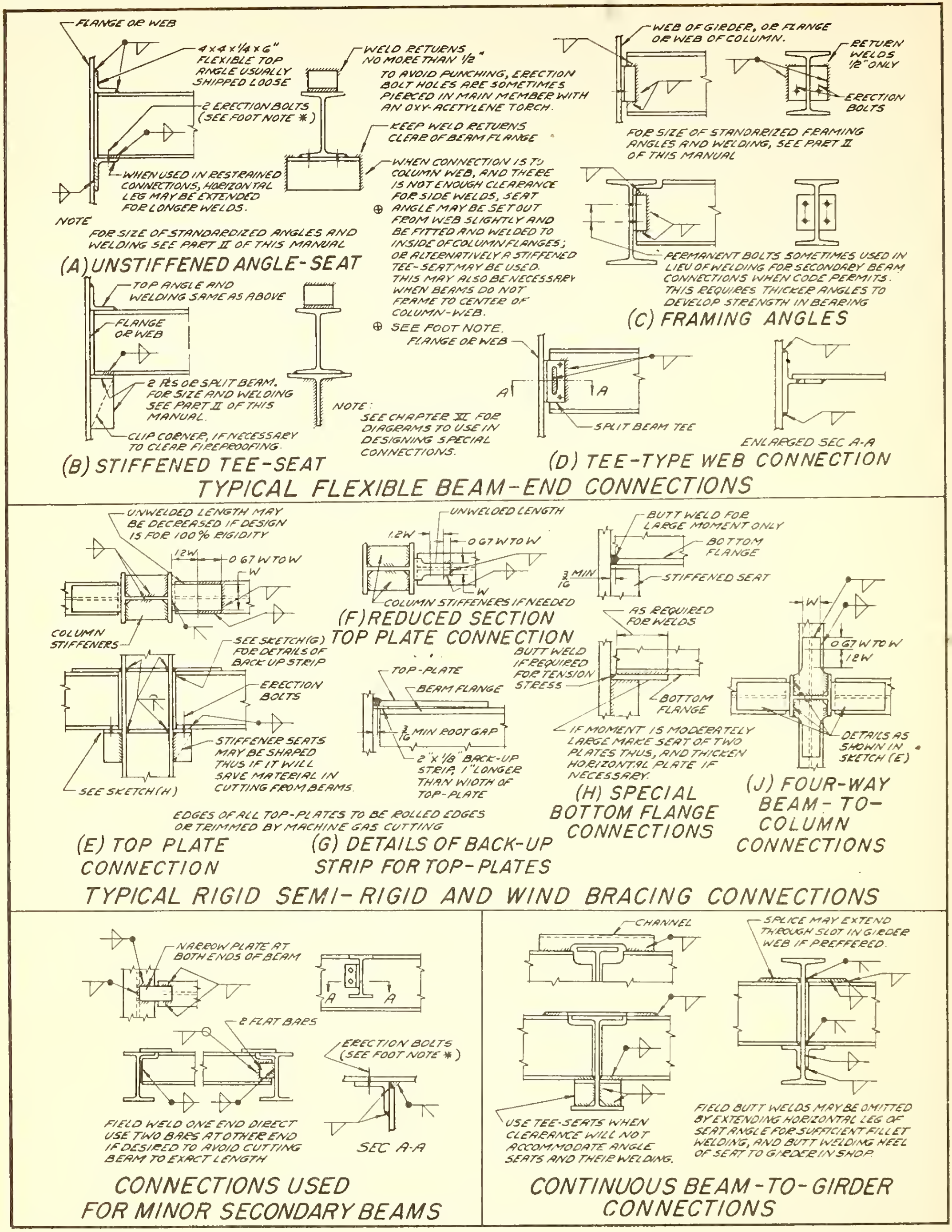
Welding Symbols

For review and ready reference purposes, the adopted AWS symbols follow:


ARC AND GAS WELDING SYMBOLS
TYPE OF WELD
BEAD
FILLET
GROOVE
SQUARE
V
BEVEL
U
J
PLUG & SLOT
FIELD WELD
WELD ALL AROUND
FLUSH
LOCATION OF WELDS
ARROW (OR NEAR) SIDE OF JOINT
OTHER (OR FAR) SIDE OF JOINT
BOTH SIDES OF JOINT
FIELD WELD
SEE NOTE 5
SIZE
7/8
FLUSH
1/4
1/8
A1
ROOT OPENING
INCLUDED ANGLE
90°
40°
3/4
1/16
SIZE
3/4
0
B2
SIZE
ROOT OPENING
SEE NOTE 5
SIZE
INCREMENT LENGTH
WELD ALL AROUND
1/2
2 - 5
3/4
OFFSET IF STAGGERED
PITCH OF INCREMENTS

1. The side of the joint to which the arrow points is the arrow (or near) side.
2. Both-sides welds of same type are of same size unless otherwise shown.
3. Symbols apply between abrupt changes in direction of joint or as dimensioned (except where all around symbol is used).
4. All welds are continuous and of user's standard proportions, unless otherwise shown.
5. Tail of arrow used for specification reference (tail may be omitted when references not used).
6. Dimensions of weld sizes, increment lengths and spacings in inches.

—COURTESY AMERICAN WELDING SOCIETY


FLANGE OR WEB
4×4×1/4×6" FLEXIBLE TOP ANGLE USUALLY SHIPPED LOOSE
2 ERECTION BOLTS (SEE FOOT NOTE *)
WHEN USED IN RESTRAINED CONNECTIONS, HORIZONTAL LEG MAY BE EXTENDED FOR LONGER WELDS.
NOTE
FOR SIZE OF STANDARDIZED ANGLES AND WELDING SEE PART II OF THIS MANUAL
WELD RETURNS NO MORE THAN 1/2"
TO AVOID PUNCHING, ERECTION BOLT HOLES ARE SOMETIMES PIERCED IN MAIN MEMBER WITH AN OXY-ACETYLENE TORCH.
KEEP WELD RETURNS CLEAR OF BEAM FLANGE
WHEN CONNECTION IS TO COLUMN WEB, AND THERE IS NOT ENOUGH CLEARANCE FOR SIDE WELDS, SEAT ⊕ ANGLE MAY BE SET OUT FROM WEB SLIGHTLY AND BE FITTED AND WELDED TO INSIDE OF COLUMN FLANGES; OR ALTERNATIVELY A STIFFENED TEE-SEAT MAY BE USED. THIS MAY ALSO BE NECESSARY WHEN BEAMS DO NOT FRAME TO CENTER OF COLUMN-WEB.
⊕ SEE FOOT NOTE.
WEB OF GIRDER, OR FLANGE OR WEB OF COLUMN.
RETURN WELDS 1/2" ONLY
ERECTION BOLTS
FOR SIZE OF STANDARDIZED FRAMING ANGLES AND WELDING, SEE PART II OF THIS MANUAL
PERMANENT BOLTS SOMETIMES USED IN LIEU OF WELDING FOR SECONDARY BEAM CONNECTIONS WHEN CODE PERMITS. THIS REQUIRES THICKER ANGLES TO DEVELOP STRENGTH IN BEARING
TOP ANGLE AND WELDING SAME AS ABOVE
FLANGE OR WEB
2 PLS OR SPLIT BEAM. FOR SIZE AND WELDING SEE PART II OF THIS MANUAL.
CLIP CORNER, IF NECESSARY TO CLEAR FIREPROOFING.
NOTE: SEE CHAPTER XI FOR DIAGRAMS TO USE IN DESIGNING SPECIAL CONNECTIONS.
FLANGE OR WEB
A
A
SPLIT BEAM TEE
ENLARGED SEC A-A
UNWELDED LENGTH MAY BE DECREASED IF DESIGN IS FOR 100% RIGIDITY
1.2W
0.67 W TO W
W
COLUMN STIFFENERS
UNWELDED LENGTH
1.2W
0.67 W TO W
W
COLUMN STIFFENERS IF NEEDED
BUTT WELD FOR LARGE MOMENT ONLY
BOTTOM FLANGE
3/16 MIN
STIFFENED SEAT
SEE SKETCH (G) FOR DETAILS OF BACK UP STRIP
ERECTION BOLTS
STIFFENER SEATS MAY BE SHAPED THUS IF IT WILL SAVE MATERIAL IN CUTTING FROM BEAMS.
SEE SKETCH (H)
TOP-PLATE
BEAM FLANGE
3/16 MIN ROOT GAP
2"×1/8" BACK-UP STRIP, 1" LONGER THAN WIDTH OF TOP-PLATE
AS REQUIRED FOR WELDS
BUTT WELD IF REQUIRED FOR TENSION STRESS
BOTTOM FLANGE
IF MOMENT IS MODERATELY LARGE MAKE SEAT OF TWO PLATES THUS, AND THICKEN HORIZONTAL PLATE IF NECESSARY.
W
0.67 W TO W
1.2W
DETAILS AS SHOWN IN SKETCH (E)
EDGES OF ALL TOP-PLATES TO BE ROLLED EDGES OR TRIMMED BY MACHINE GAS CUTTING
NARROW PLATE AT BOTH ENDS OF BEAM
A
A
2 FLAT BARS
ERECTION BOLTS (SEE FOOT NOTE *)
FIELD WELD ONE END DIRECT USE TWO BARS AT OTHER END IF DESIRED TO AVOID CUTTING BEAM TO EXACT LENGTH
SEC A-A
CHANNEL
SPLICE MAY EXTEND THROUGH SLOT IN GIRDER WEB IF PREFFERED.
USE TEE-SEATS WHEN CLEARANCE WILL NOT ACCOMMODATE ANGLE SEATS AND THEIR WELDING.
FIELD BUTT WELDS MAY BE OMITTED BY EXTENDING HORIZONTAL LEG OF SEAT ANGLE FOR SUFFICIENT FILLET WELDING, AND BUTT WELDING HEEL OF SEAT TO GIRDER IN SHOP.

(A) UNSTIFFENED ANGLE-SEAT

(B) STIFFENED TEE-SEAT

(C) FRAMING ANGLES

(D) TEE-TYPE WEB CONNECTION

TYPICAL FLEXIBLE BEAM-END CONNECTIONS

(E) TOP PLATE CONNECTION

(F) REDUCED SECTION TOP PLATE CONNECTION

(G) DETAILS OF BACK-UP STRIP FOR TOP-PLATES

(H) SPECIAL BOTTOM FLANGE CONNECTIONS

(J) FOUR-WAY BEAM-TO-COLUMN CONNECTIONS

TYPICAL RIGID SEMI-RIGID AND WIND BRACING CONNECTIONS

CONNECTIONS USED FOR MINOR SECONDARY BEAMS

CONTINUOUS BEAM-TO-GIRDER CONNECTIONS

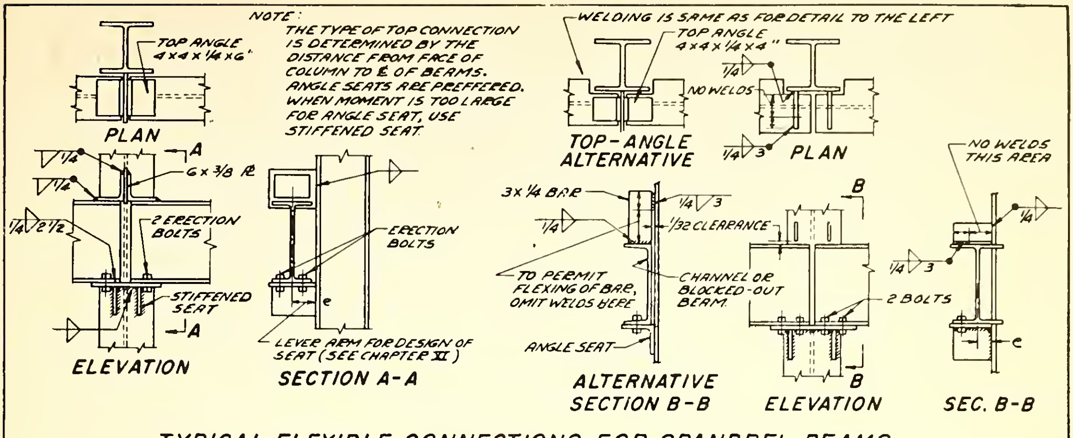
COURTESY, "AIR REDUCTION SALES CO."

Notes:

All top-plates should be trimmed and cut to shape by machine gas cutting or carefully guided manual gas cutting, to avoid rough or damaged edges as caused by shearing.

Although some tests of top plate connections have involved interior reinforcing plates simulating the constraint at a four-way connection (Sketch J, above), no tests have been made with all four of the connections loaded simultaneously.

Details using angles fitted between column flanges are reproduced from *"Practical Design of Welded Steel Structures" by H. M. Priest, published by the American Welding Society.*

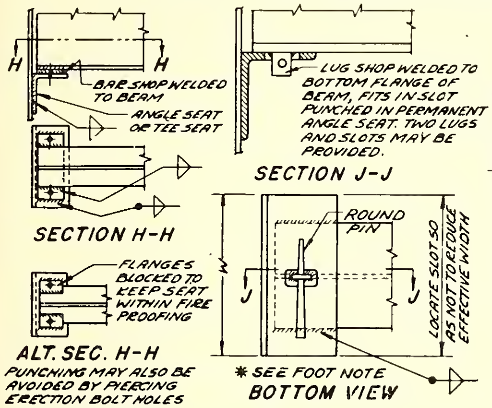

TOP ANGLE 4 x 4 x ¼ x 6"
PLAN
6 x ⅜ ℞
2 ERECTION BOLTS
STIFFENED SEAT
ELEVATION
ERECTION BOLTS
e
SECTION A-A
WELDING IS SAME AS FOR DETAIL TO THE LEFT
TOP ANGLE 4 x 4 x ¼ x 4"
NO WELDS
TOP-ANGLE ALTERNATIVE
PLAN
NO WELDS THIS AREA
3 x ¼ BAR
1/32 CLEARANCE
CHANNEL OR BLOCKED-OUT BEAM
ANGLE SEAT
2 BOLTS
ALTERNATIVE SECTION B-B
ELEVATION
SEC. B-B

NOTE: THE TYPE OF TOP CONNECTION IS DETERMINED BY THE DISTANCE FROM FACE OF COLUMN TO ℄ OF BEAMS. ANGLE SEATS ARE PREFFERED. WHEN MOMENT IS TOO LARGE FOR ANGLE SEAT, USE STIFFENED SEAT.

LEVER ARM FOR DESIGN OF SEAT (SEE CHAPTER XI)

TO PERMIT FLEXING OF BAR, OMIT WELDS HERE

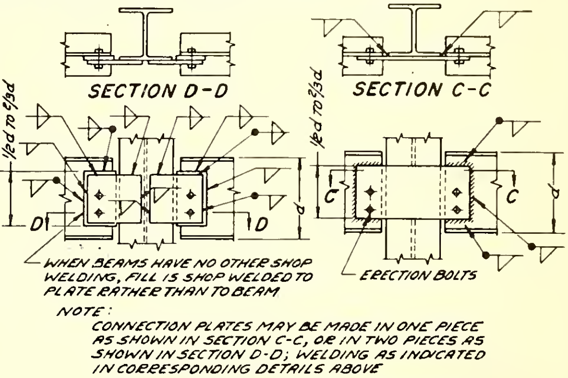
TYPICAL FLEXIBLE CONNECTIONS FOR SPANDREL BEAMS CARRYING VARIABLE LOADS SUCH AS FLOOR LOADS


H
BAR SHOP WELDED TO BEAM
ANGLE SEAT OR TEE SEAT
SECTION H-H
FLANGES BLOCKED TO KEEP SEAT WITHIN FIRE PROOFING
ALT. SEC. H-H
SECTION J-J
ROUND PIN
J
W
LOCATE SLOT SO AS NOT TO REDUCE EFFECTIVE WIDTH
✻ SEE FOOT NOTE
BOTTOM VIEW

LUG SHOP WELDED TO BOTTOM FLANGE OF BEAM, FITS IN SLOT PUNCHED IN PERMANENT ANGLE SEAT. TWO LUGS AND SLOTS MAY BE PROVIDED.

PUNCHING MAY ALSO BE AVOIDED BY PIERCING ERECTION BOLT HOLES WITH A GAS TORCH.

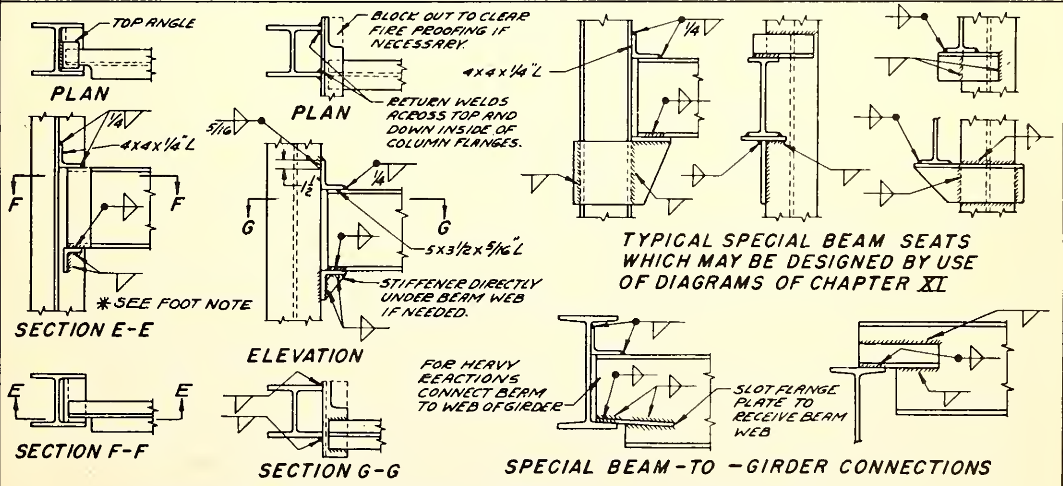
METHODS OF AVOIDING THE PUNCHING OF HOLES IN BEAM FLANGES FOR ERECTION BOLTS.


SECTION D-D
SECTION C-C
½d to ⅔d
D
C
d
ERECTION BOLTS

WHEN BEAMS HAVE NO OTHER SHOP WELDING, FILL IS SHOP WELDED TO PLATE RATHER THAN TO BEAM

NOTE: CONNECTION PLATES MAY BE MADE IN ONE PIECE AS SHOWN IN SECTION C-C, OR IN TWO PIECES AS SHOWN IN SECTION D-D; WELDING AS INDICATED IN CORRESPONDING DETAILS ABOVE

CONNECTIONS FOR SPANDREL BEAMS OF LIMITED SPAN CARRYING STEADY LOADS.


TOP ANGLE
PLAN
4 x 4 x ¼" L
F
✻ SEE FOOT NOTE
SECTION E-E
E
SECTION F-F
PLAN
5/16
G
5 x 3½ x 5/16" L
ELEVATION
SECTION G-G
4 x 4 x ¼" L
SLOT FLANGE PLATE TO RECEIVE BEAM WEB

BLOCK OUT TO CLEAR FIRE PROOFING IF NECESSARY.

RETURN WELDS ACROSS TOP AND DOWN INSIDE OF COLUMN FLANGES.

STIFFENER DIRECTLY UNDER BEAM WEB IF NEEDED.

TYPICAL SPECIAL BEAM SEATS WHICH MAY BE DESIGNED BY USE OF DIAGRAMS OF CHAPTER XI

FOR HEAVY REACTIONS CONNECT BEAM TO WEB OF GIRDER

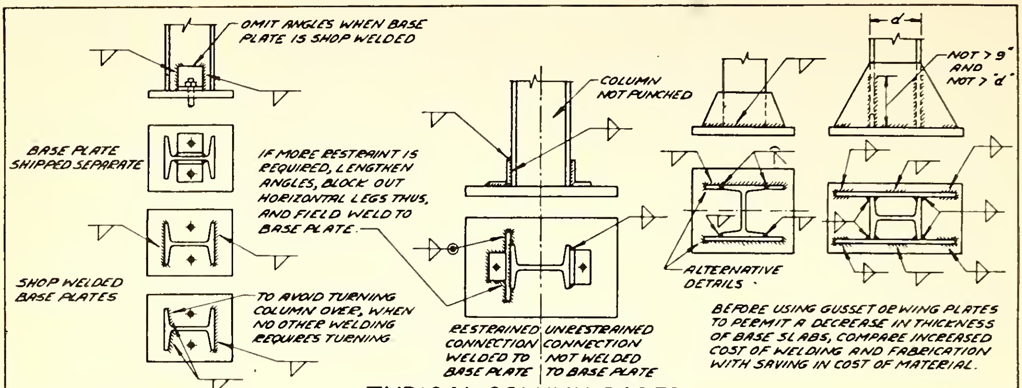
SPECIAL BEAM-TO-GIRDER CONNECTIONS

MISCELLANEOUS SPECIAL BEAM-END CONNECTIONS

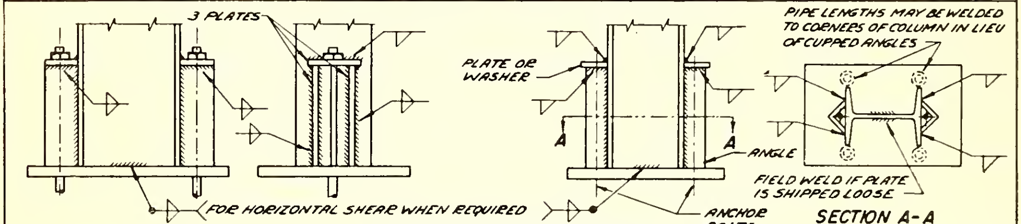
COURTESY, "AIR REDUCTION SALES CO."

Notes:

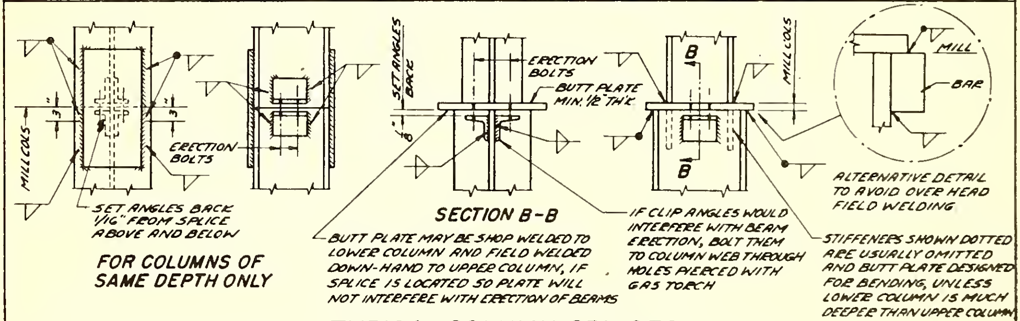
Details using angles fitted between column flanges are reproduced from "*Practical Design of Welded Steel Structures*" *by H. M. Priest, published by the American Welding Society.*


OMIT ANGLES WHEN BASE PLATE IS SHOP WELDED
BASE PLATE SHIPPED SEPARATE
IF MORE RESTRAINT IS REQUIRED, LENGTHEN ANGLES, BLOCK OUT HORIZONTAL LEGS THUS, AND FIELD WELD TO BASE PLATE.
SHOP WELDED BASE PLATES
TO AVOID TURNING COLUMN OVER, WHEN NO OTHER WELDING REQUIRES TURNING
COLUMN NOT PUNCHED
RESTRAINED CONNECTION WELDED TO BASE PLATE
UNRESTRAINED CONNECTION NOT WELDED TO BASE PLATE
d
NOT > 9" AND NOT > "d"
ALTERNATIVE DETAILS
BEFORE USING GUSSET OR WING PLATES TO PERMIT A DECREASE IN THICKNESS OF BASE SLABS, COMPARE INCREASED COST OF WELDING AND FABRICATION WITH SAVING IN COST OF MATERIAL.

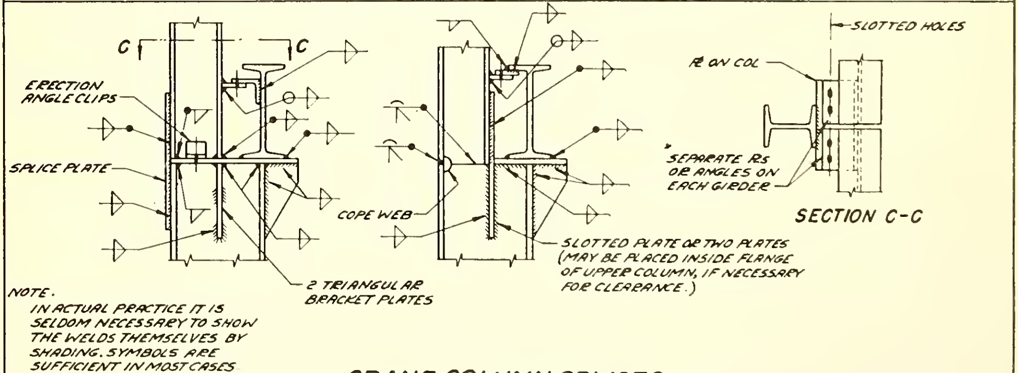
TYPICAL COLUMN BASES


3 PLATES
FOR HORIZONTAL SHEAR WHEN REQUIRED
PLATE OR WASHER
A
A
ANGLE
ANCHOR BOLTS
PIPE LENGTHS MAY BE WELDED TO CORNERS OF COLUMN IN LIEU OF CUPPED ANGLES
FIELD WELD IF PLATE IS SHIPPED LOOSE
SECTION A-A

CRANE COLUMN BASES


MILL COLS
3"
3"
ERECTION BOLTS
SET ANGLES BACK 1/16" FROM SPLICE ABOVE AND BELOW
FOR COLUMNS OF SAME DEPTH ONLY
SET ANGLES BACK 1/8"
ERECTION BOLTS
BUTT PLATE MIN. 1/2" TH'K
SECTION B-B
BUTT PLATE MAY BE SHOP WELDED TO LOWER COLUMN AND FIELD WELDED DOWN-HAND TO UPPER COLUMN, IF SPLICE IS LOCATED SO PLATE WILL NOT INTERFERE WITH ERECTION OF BEAMS
B
B
MILL COLS
IF CLIP ANGLES WOULD INTERFERE WITH BEAM ERECTION, BOLT THEM TO COLUMN WEB THROUGH HOLES PIERCED WITH GAS TORCH
MILL
BAR
ALTERNATIVE DETAIL TO AVOID OVERHEAD FIELD WELDING
STIFFENERS SHOWN DOTTED ARE USUALLY OMITTED AND BUTT PLATE DESIGNED FOR BENDING, UNLESS LOWER COLUMN IS MUCH DEEPER THAN UPPER COLUM

TYPICAL COLUMN SPLICES


C
C
ERECTION ANGLE CLIPS
SPLICE PLATE
COPE WEB
2 TRIANGULAR BRACKET PLATES
SLOTTED PLATE OR TWO PLATES (MAY BE PLACED INSIDE FLANGE OF UPPER COLUMN, IF NECESSARY FOR CLEARANCE.)
SLOTTED HOLES
PL ON COL
SEPARATE PLS OR ANGLES ON EACH GIRDER
SECTION C-C
NOTE.
IN ACTUAL PRACTICE IT IS SELDOM NECESSARY TO SHOW THE WELDS THEMSELVES BY SHADING. SYMBOLS ARE SUFFICIENT IN MOST CASES

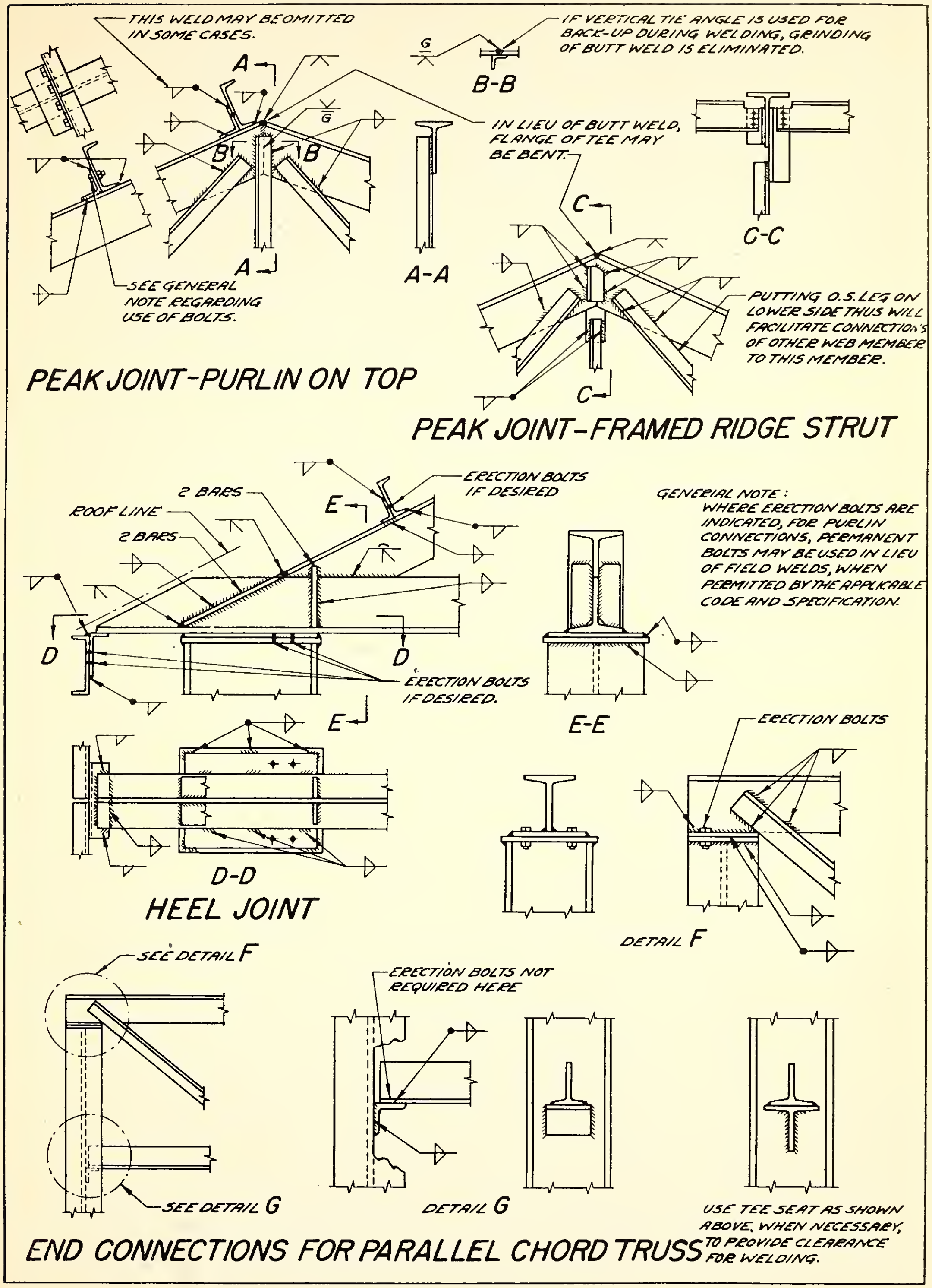
CRANE COLUMN SPLICES

COURTESY, "AIR REDUCTION SALES CO."

Notes:

If lap-welded splice-bars are used at column splices, a short gap should be left in the welding, in way of the milled joint.

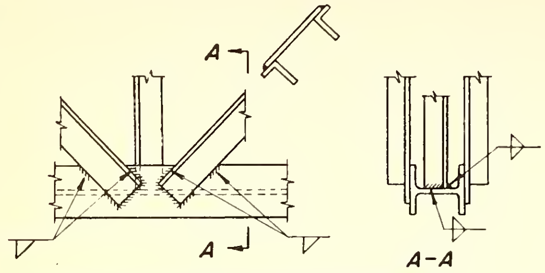
Splices and connections for girders supporting crane runways lend themselves better to detailing to provide fatigue resistance when the members are designed as continuous beams, with occasional provisions for expansion at their bearings on supports.


THIS WELD MAY BE OMITTED IN SOME CASES.
A
B
B
A
G
G
SEE GENERAL NOTE REGARDING USE OF BOLTS.
IF VERTICAL TIE ANGLE IS USED FOR BACK-UP DURING WELDING, GRINDING OF BUTT WELD IS ELIMINATED.
B-B
IN LIEU OF BUTT WELD, FLANGE OF TEE MAY BE BENT.
A-A
PEAK JOINT-PURLIN ON TOP
C
C
C-C
PUTTING O.S. LEG ON LOWER SIDE THUS WILL FACILITATE CONNECTIONS OF OTHER WEB MEMBER TO THIS MEMBER.
PEAK JOINT-FRAMED RIDGE STRUT
2 BARS
ROOF LINE
2 BARS
E
ERECTION BOLTS IF DESIRED
D
D
ERECTION BOLTS IF DESIRED.
E
E-E
GENERAL NOTE: WHERE ERECTION BOLTS ARE INDICATED, FOR PURLIN CONNECTIONS, PERMANENT BOLTS MAY BE USED IN LIEU OF FIELD WELDS, WHEN PERMITTED BY THE APPLICABLE CODE AND SPECIFICATION.
D-D
HEEL JOINT
ERECTION BOLTS
DETAIL F
SEE DETAIL F
SEE DETAIL G
ERECTION BOLTS NOT REQUIRED HERE
DETAIL G
USE TEE SEAT AS SHOWN ABOVE, WHEN NECESSARY, TO PROVIDE CLEARANCE FOR WELDING.
END CONNECTIONS FOR PARALLEL CHORD TRUSS

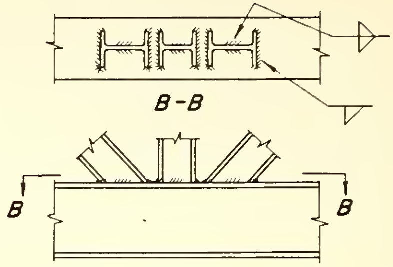
COURTESY, "AIR REDUCTION SALES CO."

Note:

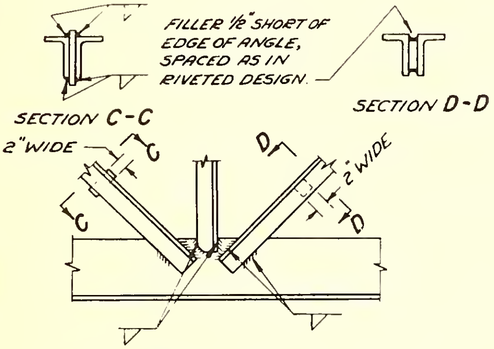
Connections at ends of tension or compression members of trusses in buildings must develop the strength required by the total stresses, but in no case less than 50 per cent of the effective strength of the material connected.



H- SECTION WITH WEB HORIZONTAL

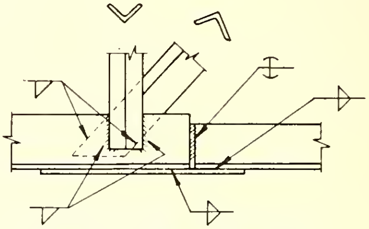


H-SECTION WITH WEB VERTICAL

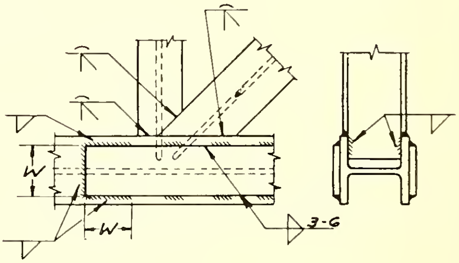

SECTION C-C
SECTION D-D
2" WIDE
C
C
D
D
2" WIDE

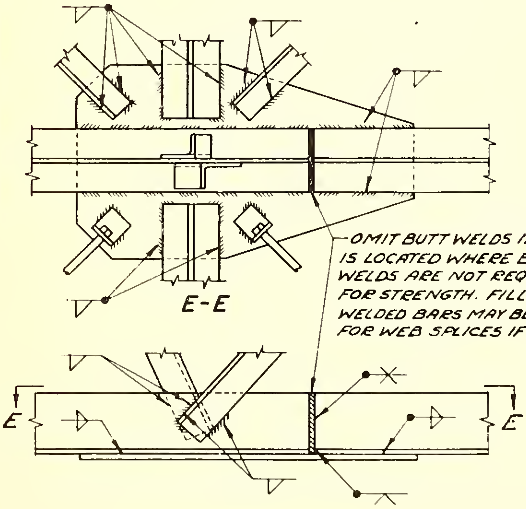
FILLER ½" SHORT OF EDGE OF ANGLE, SPACED AS IN RIVETED DESIGN.

TWO ANGLE WEB MEMBERS



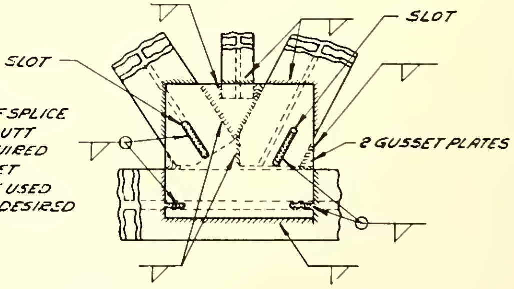
CUPPED WEB MEMBERS





OMIT BUTT WELDS IF SPLICE IS LOCATED WHERE BUTT WELDS ARE NOT REQUIRED FOR STRENGTH. FILLET WELDED BARS MAY BE USED FOR WEB SPLICES IF DESIRED

FIELD SPLICE


SLOT
SLOT
2 GUSSET PLATES

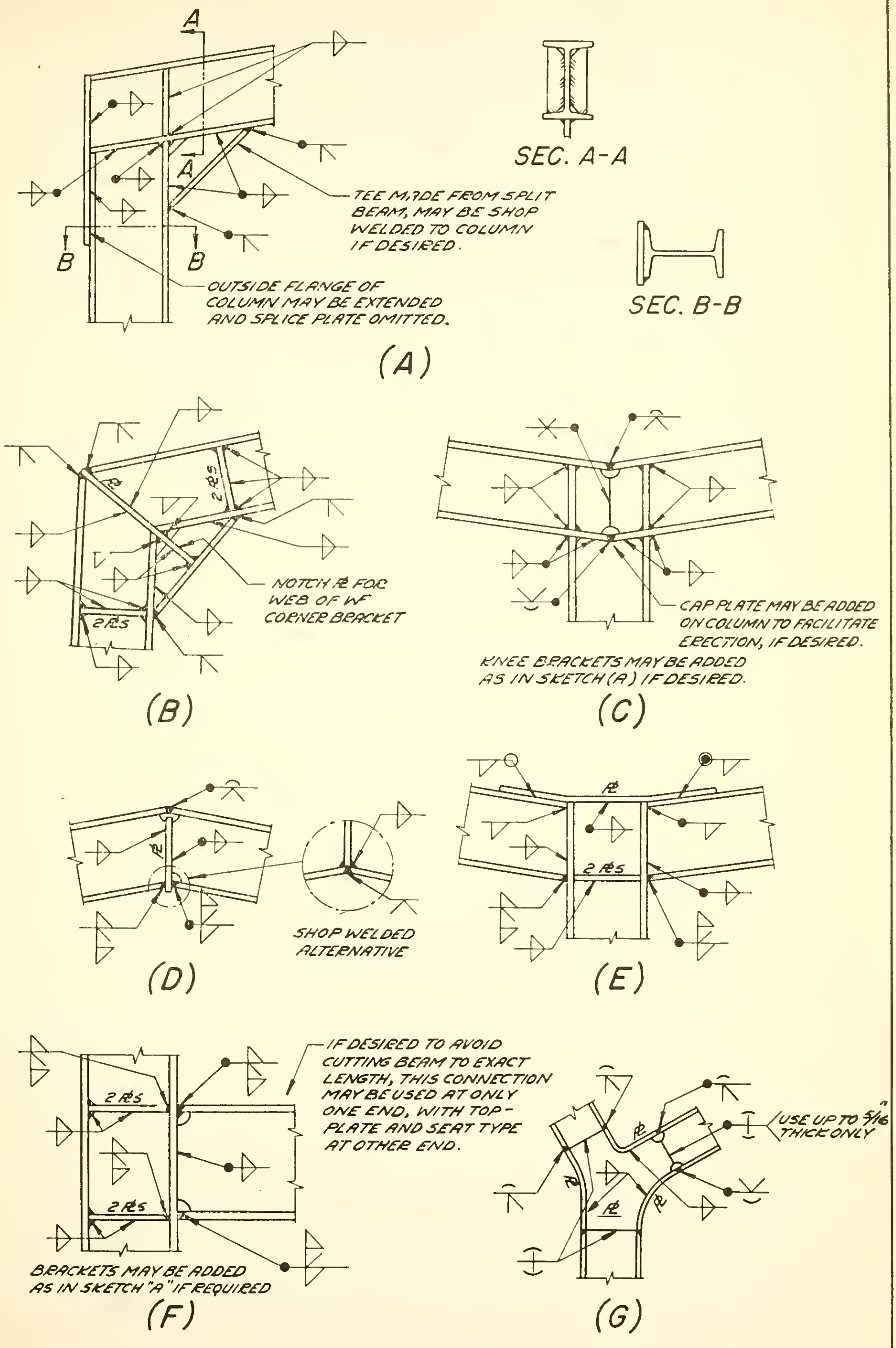
NOTE:
SLOTS ARE LOCATED TO APPROXIMATELY BALANCE ECCENTRICITIES PRODUCED BY OTHER WELDS, WHOSE PROPORTIONS ARE DETERMINED BY THE ARRANGEMENT OF THE MEMBERS

HEAVY TRUSS JOINTS

BOTTOM CHORD JOINTS AND SPLICES

COURTESY, "AIR REDUCTION SALES CO."

COURTESY, "AIR REDUCTION SALES CO."



TEE MADE FROM SPLIT BEAM, MAY BE SHOP WELDED TO COLUMN IF DESIRED.

OUTSIDE FLANGE OF COLUMN MAY BE EXTENDED AND SPLICE PLATE OMITTED.

NOTCH PL FOR WEB OF WF CORNER BRACKET

CAP PLATE MAY BE ADDED ON COLUMN TO FACILITATE ERECTION, IF DESIRED.

KNEE BRACKETS MAY BE ADDED AS IN SKETCH (A) IF DESIRED.

SHOP WELDED ALTERNATIVE

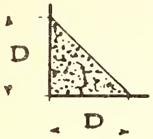
IF DESIRED TO AVOID CUTTING BEAM TO EXACT LENGTH, THIS CONNECTION MAY BE USED AT ONLY ONE END, WITH TOP-PLATE AND SEAT TYPE AT OTHER END.

BRACKETS MAY BE ADDED AS IN SKETCH "A" IF REQUIRED

USE UP TO 5/16" THICK ONLY

TYPICAL RIGID FRAME CONNECTIONS FOR SHORT SPANS

ALLOWABLE LOADS ON FILLET WELDS



$$P = 9.6DL$$

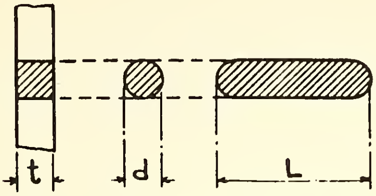
(Based on 13,600 p.s.i. shear on throat = 9.6 K/□" on leg)

D = Weld Size in inches
L = Weld Length in inches
P = Allowable load in Kips

D L	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1
.5	.6	.9	1.2	1.5	1.8	2.1	2.4	3.	3.6	4.2	4.8
1.0	1.2	1.8	2.4	3.0	3.6	4.2	4.8	6.	7.2	8.4	9.6
1.5	1.8	2.7	3.6	4.5	5.4	6.3	7.2	9.	10.8	12.6	14.4
2.0	2.4	3.6	4.8	6.0	7.2	8.4	9.6	12.	14.4	16.8	19.2
2.5	3.0	4.5	6.0	7.5	9.0	10.5	12.0	15.	18.0	21.0	24.0
3.0	3.6	5.4	7.2	9.0	10.8	12.6	14.4	18.	21.6	25.2	28.8
3.5	4.2	6.3	8.4	10.5	12.6	14.7	16.8	21.	25.2	29.4	33.6
4.0	4.8	7.2	9.6	12.0	14.4	16.8	19.2	24.	28.8	33.6	38.4
4.5	5.4	8.1	10.8	13.5	16.2	18.9	21.6	27.	32.4	37.8	43.2
5.0	6.0	9.0	12.0	15.0	18.0	21.0	24.0	30.	36.0	42.0	48.0
5.5	6.6	9.9	13.2	16.5	19.8	23.1	26.4	33.	39.6	46.2	52.8
6.0	7.2	10.8	14.4	18.0	21.6	25.2	28.8	36.	43.2	50.4	57.6
6.5	7.8	11.7	15.6	19.5	23.4	27.3	31.2	39.	46.8	54.6	62.4
7.0	8.4	12.6	16.8	21.0	25.2	29.4	33.6	42.	50.4	58.8	67.2
7.5	9.0	13.5	18.0	22.5	27.0	31.5	36.0	45.	54.0	63.0	72.0
8.0	9.6	14.4	19.2	24.0	28.8	33.6	38.4	48.	57.6	67.2	76.8
8.5	10.2	15.3	20.4	25.5	30.6	35.7	40.8	51.	61.2	71.4	81.6
9.0	10.8	16.2	21.6	27.0	32.4	37.8	43.2	54.	64.8	75.6.	86.4
9.5	11.4	17.1	22.8	28.5	34.2	39.9	45.6	57.	68.4	79.8	91.2
10.0	12.0	18.0	24.0	30.0	36.0	42.0	48.0	60.	72.0	84.0	96.0
10.5	12.6	18.9	25.2	31.5	37.8	44.1	50.4	63.	75.6	88.2	100.8
11.0	13.2	19.8	26.4	33.0	39.6	46.2	52.8	66.	79.2	92.4	105.6
11.5	13.8	20.7	27.6	34.5	41.4	48.3	55.2	69.	82.8	96.6	110.4
12.	14.4	21.6	28.8	36.	43.2	50.4	57.6	72.	86.4	100.8	115.2
13.	15.6	23.4	31.2	39.	46.8	54.6	62.4	78.	93.6	109.2	124.8
14.	16.8	25.2	33.6	42.	50.4	58.8	67.2	84.	100.8	117.6	134.4
15.	18.0	27.0	36.0	45.	54.0	63.0	72.0	90.	108.0	126.0	144.0
16.	19.2	28.8	38.4	48.	57.6	67.2	76.8	96.	115.2	134.4	153.6
17.	20.4	30.6	40.8	51.	61.2	71.4	81.6	102.	122.4	142.8	163.2
18.	21.6	32.4	43.2	54.	64.8	75.6	86.4	108.	129.6	151.2	172.8
19.	22.8	34.2	45.6	57.	68.4	79.8	91.2	114.	136.8	159.6	182.4
20.	24.0	36.0	48.0	60.	72.0	84.0	96.	120.	144.0	168.0	192.0
21.	25.2	37.8	50.4	63.	75.6	88.2	100.8	126.	151.2	176.4	201.6
22.	26.4	39.6	52.8	66.	79.2	92.4	105.6	132.	158.4	184.8	211.2
23.	27.6	41.4	55.2	69.	82.8	96.6	110.4	138.	165.6	193.2	220.8
24.	28.8	43.2	57.6	72.	86.4	100.8	115.2	144.	172.8	201.6	230.4
25.	30.0	45.0	60.0	75.	90.0	105.0	120.0	150.	180.0	210.0	240.0
26.	31.2	46.8	62.4	78.	93.6	109.2	124.8	156.	187.2	218.4	249.6
27.	32.4	48.6	64.8	81.	97.2	113.4	129.6	162.	194.4	226.8	259.2
28.	33.6	50.4	67.2	84.	100.8	117.6	134.4	168.	201.6	235.2	268.8
29.	34.8	52.2	69.6	87.	104.4	121.8	139.2	174.	208.8	243.6	278.4
30.	36.0	54.0	72.0	90.	108.0	126.0	144.0	180.	216.0	252.0	288.0

COURTESY, "AIR REDUCTION SALES CO."

PLUG & SLOT WELDS



AISC Specifications limit plug and slot weld dimensions as follows:
Max. t = 1" Max. L = 10 t.
Min. d = t + 5/16 Max d = 2 1/4 t

t	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1
d min.	9/16	9/16	11/16	11/16	13/16	13/16	15/16	15/16	1 1/16	1 1/16	1 3/16	1 3/16	1 5/16	1 5/16
d max.	9/16	9/16	11/16	7/8	1	1 1/8	1 1/4	1 3/8	1 9/16	1 11/16	1 13/16	1 15/16	2 1/8	2 1/4
L max.	1 7/8	2 1/2	3 1/8	3 3/4	4 3/8	5	5 5/8	6 1/4	6 7/8	7 1/2	8 1/8	8 3/4	9 3/8	10

SHEAR VALUES AT 13600 p.s.i. AWS.

d	Plug ●	Half Plug ◐	Length of Slot L															
			1	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	5 1/2	6	6 1/2	7	8	9	10
5/16	1.04	.52	4.0	6.1	8.2													
3/8	1.50	.75	4.7	7.2	9.8	12.3	14.9	17.4										
7/16	2.04	1.02	5.4	8.4	11.3	14.3	17.3	20.3										
1/2	2.67	1.33	6.1	9.5	12.9	16.3	19.7	23.1	26.5	29.9	33.3							
9/16	3.38	1.69	6.7	10.6	14.4	18.2	22.0	25.9	29.7	33.5	37.3							
5/8	4.17	2.09	7.4	11.6	15.9	20.1	24.4	28.6	32.9	37.1	41.4	45.6	50.0					
11/16	5.05	2.53	8.0	12.7	17.3	22.0	26.7	31.4	36.0	40.7	45.4	50.1	54.7					
3/4	6.01	3.00	8.6	13.7	18.8	23.9	29.0	34.1	39.2	44.3	49.4	54.5	59.6	64.7	69.8			
13/16	7.05	3.53	9.1	14.7	20.2	25.7	31.2	36.8	42.3	47.8	53.3	58.9	64.4	69.9	75.4			
7/8	8.18	4.09	9.7	15.6	21.6	27.5	33.5	39.4	45.4	51.3	57.3	63.2	69.2	75.1	81.1	93.0		
15/16	9.39	4.69	10.2	16.6	22.9	29.3	35.7	42.1	48.4	54.8	61.2	67.6	73.9	80.3	86.7	99.4	112	125
1	10.68	5.34	10.7	17.5	24.3	31.1	37.9	44.7	51.5	58.3	65.1	71.9	78.7	85.5	92.3	106	119	133
1 1/16	12.06	6.03	11.2	18.4	25.6	32.8	40.1	47.3	54.5	61.7	69.0	76.2	83.4	90.6	97.9	112	127	141
1 1/8	13.52	6.76	11.6	19.3	26.9	34.6	42.2	49.9	57.5	65.2	72.8	80.5	88.1	95.8	103	119	134	149
1 3/16	15.06	7.53	12.0	20.1	28.2	36.3	44.3	52.4	60.5	68.6	76.6	84.7	92.8	101	109	125	141	157
1 1/4	16.69	8.35	12.4	20.9	29.4	37.9	46.4	54.9	63.4	71.9	80.4	88.9	97.4	106	114	131	148	165
1 3/8	20.19	10.09	13.2	22.5	31.9	41.2	50.6	59.9	69.3	78.6	88.0	97.3	107	116	125	144	163	181
1 1/2	24.03	12.02	13.8	24.0	34.2	44.4	54.6	64.8	75.0	85.2	95.4	106	116	126	136	157	177	197
1 5/8	28.21	14.10	14.4	25.4	36.5	47.5	58.6	69.6	80.7	91.7	103	114	125	136	147	169	191	213
1 3/4	32.71	16.36	14.9	26.8	38.7	50.6	62.5	74.4	86.3	98.2	110	122	134	146	158	181	205	229
1 7/8	37.55	18.77	15.2	28.0	40.7	53.5	66.2	79.0	91.7	105	117	130	143	156	168	194	219	245
2	42.73	21.37	15.5	29.1	42.7	56.3	69.9	83.5	97.1	111	124	138	152	165	179	206	233	260
2 1/8	48.37	24.18	15.7	30.2	44.6	59.1	73.5	88.0	102	117	131	146	160	175	189	218	247	276
2 1/4	54.08	27.04	15.8	31.1	46.4	61.7	77.0	92.3	108	123	138	154	169	184	199	230	261	291

Values to left and below heavy line are in accord with AISC Spec's.

COURTESY, "AIR REDUCTION SALES CO."

TIMBER AND WOOD

This section of the Manual, if the subject were adequately treated, would cover scores of pages. The published data as distributed by the various organizations engaged in the research and promotion of Timber (or Wood) Structures is comprehensive and complete. It is therefore believed advisable to refer the designing engineer to such primary sources, wherein all the desired information may be secured at first hand. The inclusion of such information in this book—useless if not wholly complete—would therefore serve no useful purpose.

The work of the Forest Products Laboratory, Forest Service, United States Department of Agriculture, Madison, Wisconsin, is of course fundamental. It is perhaps unfortunate that there is no nation-wide common denominator as concerns the application of observed or proven results.

In the design of Timber Structures utilizing the TECO type of Timber Connectors (Split Rings, Toothed Rings, Spike Grids, Claw Plates, etc.) it is most advisable for the Designer to avail himself of the information provided by Timber Engineering Company, whose home office address is 1319 Eighteenth Street, N. W., Washington 6, D. C. Too, the National Lumber Manufacturers Association, Washington, D. C., will be glad, I am sure, to furnish such things as National Design Specifications, if requested, as well as detailed information on other phases of timber design and use.

Timber Structures, Inc., with home offices in Portland, Oregon, will be more than willing to provide complete data on glued laminated or bolted structures.

It is of course impossible to list all the organizations which have done so much in developing the use of Wood. In addition to those already named, I would like to call attention to the following, however:

West Coast Lumbermen's Association.
Southern Pine Association.
Western Pine Association.
Arkansas Soft Pine Bureau.
Douglas Fir Plywood Association.

The question of proper fibre stresses to be used in design must largely be adjusted with the building code or other authorities exercising supervision over specific structural design problems. Lacking further authoritative data, I am republishing the original information which I felt to be essentially sound.

F = Maximum Fiber Stress.
E = Modulus of Elasticity.
V = Maximum unit shear, in².
Loads given are total loads, and include weight of joist or beam and all live and dead loads.

WOOD JOIST AND BEAMS

ALLOWABLE LOADS, UNIFORMLY DISTRIBUTED

FOR PLASTER CEILINGS

MAXIMUM DEFLECTION 1/360 SPAN

For Fiber Stresses,
F = 1,200
F = 1,600

STRESS	KIND WOOD	SPAN IN FEET	SPACING CT. TO CT.	Allowable Loads per Sq. Ft. for Joist Sizes as Shown															Total Allowable Loads for Beams One Inch Actual Width For Depth as Shown						
				2x4	2x6	2x8	3x8	2x10	3x10	2x12	3x12	4x12	2x14	3x14	4x14	2x16	3x16	4x16							
				1⅝x3⅝	1⅝x5⅝	1⅝x7½	2⅝x7½	1⅝x9½	2⅝x9½	1⅝x11½	2⅝x11½	3⅝x11½	1⅝x13½	2⅝x13½	3⅝x13½	1⅝x15½	2⅝x15½	3⅝x15½	3⅝	5½	7½	9½	11½	13½	15½
F = 1,200 Lbs. per Sq. In. E = 1,600,000 V = 100 Lbs. per Sq. In.	No. 1 Common, Southern Pine; Common Coast Douglas Fir.	5	12	114	244														351	750					
			16	85	183																				
		6	12	71	191	270	437												261	704	1000				
			16	53	143	202	328																		
		7	12	45	140	233	375	294	475										192	602	1000	1267			
			16	34	105	175	281	221	356																
		8	12	30	107	190	308	258	416										147	526	938	1267			
			16	23	80	142	231	193	312																
		9	12		78	150	243	228	370	277	448	618								433	833	1267	1535		
			16		58	113	182	171	277	208	336	464													
		10	12		57	122	197	195	315	249	403	556								351	750	1200	1535		
			16		43	92	148	146	236	187	302	417													
		11	12		43	101	162	162	261	227	366	506	266	430	593					290	680	1094	1535	1800	
			16		32	76	122	122	196	170	275	380	200	322	445										
		12	12		33	78	126	135	219	198	321	444	244	393	544					244	578	1000	1470	1800	
			16		25	59	95	101	164	148	241	333	183	295	408										
		14	12			49	80	100	161	146	236	326	202	325	450	240	388	536			425	858	1260	1735	2070
			16			37	60	75	121	110	177	245	152	244	338	180	291	402							
		16	12			33	53	67	108	112	181	250	154	250	345	203	328	453			326	662	1104	1520	2000
			16			25	40	50	81	84	136	188	115	188	259	152	246	340							
		18	12					47	76	84	135	187	122	197	272	161	260	358				522	928	1350	1780
			16					35	57	63	101	140	92	148	204	121	195	269							
		20	12					34	55	61	98	135	99	160	220	130	210	290				423	750	1215	1600
			16					26	41	46	74	101	74	120	165	98	158	218							
		22	12							46	74	102	74	120	165	107	174	240					622	1004	1455
			16							35	56	77	56	90	124	80	130	180							
		24	12							35	57	79	57	92	127	86	140	193					522	844	1276
			16							26	43	59	43	69	95	65	105	145							
		26	12										45	72	100	68	110	151						720	1088
			16										34	54	75	51	83	113							
		28	12										36	58	80	54	88	121						620	940
			16										27	44	60	41	66	91							
		30	12													44	71	98							817
			16													33	53	74							
F = 1,600 Lbs. per Sq. In. E = 1,600,000 V = 150 Lbs. per Sq. In.	Structural Square Edge Southern Pine; Select Coast Douglas Fir.	5	12	152	366														468	1125					
			16	114	275																				
		6	12	71	254	406	655												261	938	1500				
			16	53	191	305	491																		
		7	12	45	167	331	535	441	713										192	718	1426	1900			
			16	34	125	248	402	331	535																
		8	12	30	111	254	411	386	624										147	548	1252	1900			
			16	23	83	191	308	290	468																
		9	12		78	187	301	321	518	415	670	925								433	1030	1780	2300		
			16		58	140	226	241	388	311	503	694													
		10	12		57	136	219	275	444	374	604	834								351	835	1690	2300		
			16		43	102	164	206	333	281	452	625													
		11	12		43	102	165	207	334	314	508	702	399	645	890					290	690	1400	2130	2700	
			16		32	77	124	155	251	235	381	526	299	484	668										
		12	12		33	78	126	159	257	266	429	592	364	588	813					244	578	1176	1960	2690	
			16		25	59	95	119	193	200	322	444	273	441	610										
		14	12			49	80	100	162	178	288	397	268	434	600	353	570	788			425	865	1534	2315	3040
			16			37	60	75	122	133	216	298	201	333	450	265	428	591							
		16	12			33	53	67	108	119	192	266	193	312	430	271	438	605			326	662	1174	1900	2670
			16			25	40	50	81	89	144	200	145	234	322	203	329	454							
		18	12					47	76	84	135	187	135	218	302	205	331	457				522	928	1500	2270
			16					35	57	63	101	140	101	164	227	154	248	343							
		20	12					34	55	61	98	135	99	160	220	150	242	333				423	750	1215	1840
			16					26	41	46	74	101	74	120	165	113	182	250							
		22	12							46	74	102	74	120	165	112	181	250					622	1004	1520
			16							35	56	77	56	90	124	84	136	188							
		24	12							35	57	79	57	92	127	86	140	193					522	844	1276
			16							26	43	59	43	69	95	65	105	145							
		26	12										45	72	100	68	110	151						720	1088
			16										34	54	75	51	83	113							
		28	12										36	58	80	54	88	121						620	940
			16										27	44	60	41	66	91							
		30	12													44	71	98							817
			16													33	53	74							

WOOD JOIST AND BEAMS

ALLOWABLE LOADS, UNIFORMLY DISTRIBUTED

AS DETERMINED BY BENDING ONLY

DEFLECTION AND SHEAR NOT CONSIDERED

F = Maximum Fiber Stress.
E = Modulus of Elasticity.
Loads given are total loads, and include weight of joist or beam and all live and dead loads.

Tabulated for Fiber Stress:
F=1,200 and F=1,600
(for F=1200)
For F=1000: Load given x0.833
" 1300: " " x1.083
" 1400: " " x1.167
" 1500: " " x1.250
" 1800: " " x1.500
" 2000: " " x1.667

STRESS	KIND WOOD	SPAN IN FEET	SPACING CT. TO CT.	Allowable Loads per Sq. Ft. for Joist Sizes as Shown															Total Allowable Loads for Beams One Inch Actual Width For Depth as Shown						
				2x4	2x6	2x8	3x8	2x10	3x10	2x12	3x12	4x12	2x14	3x14	4x14	2x16	3x16	4x16							
				1⅝x3⅝	1⅝x5⅝	1⅝x7½	2⅝x7½	1⅝x9½	2⅝x9½	1⅝x11½	2⅝x11½	3⅝x11½	1⅝x13½	2⅝x13½	3⅝x13½	1⅝x15½	2⅝x15½	3⅝x15½	3⅝	5⅝	7½	9½	11½	13½	15½
F=1,200 Lbs. per Sq. In. E=1,600,000 V= Varies	No. 1 Common, Southern Pine; Common Coast Douglas Fir.	5	12	114	274														351	844					
			16	85	206																				
		6	12	79	191	338	546												292	704	1250				
			16	59	143	254	410																		
		7	12	58	140	248	402	400	645										250	602	1070	1720			
			16	44	105	186	302	300	484																
		8	12	44	107	190	308	304	491										219	526	938	1500			
			16	33	80	142	231	228	368																
		9	12		85	150	243	241	389	354	572	790								468	833	1336	1960		
			16		64	113	182	181	292	265	428	593													
		10	12		69	122	197	195	315	287	464	640								421	750	1200	1765		
			16		52	92	148	146	236	215	348	480													
		11	12		57	101	162	162	261	237	382	528	327	528	728					383	680	1094	1600	2210	
			16		43	76	122	122	196	178	286	396	253	396	546										
		12	12		48	85	137	135	219	198	321	444	273	442	610					351	625	1000	1470	2020	
			16		36	64	103	101	164	148	241	333	205	332	458										
		14	12			62	101	100	161	146	236	326	202	325	450	265	427	591			535	858	1260	1735	2280
			16			47	76	75	121	110	177	245	152	244	338	199	321	444							
		16	12			48	77	76	123	112	181	250	154	250	345	203	328	453			468	752	1104	1520	2000
			16			36	58	57	92	84	136	188	115	188	259	152	246	340							
		18	12					60	97	89	143	197	122	197	272	161	260	358				668	980	1350	1780
			16					45	73	67	107	148	92	148	204	121	195	269							
		20	12					49	79	72	116	160	99	160	220	130	210	290				600	882	1215	1600
			16					37	59	54	87	120	74	120	165	98	158	218							
		22	12							59	96	132	81	132	182	107	174	240					802	1104	1455
			16							44	72	99	61	99	137	80	130	180							
		24	12							50	80	111	68	111	153	90	146	201					735	1012	1333
			16							38	60	83	51	83	115	68	110	151							
		26	12										58	94	130	77	124	172						935	1230
			16										44	71	98	58	93	129							
		28	12										50	82	112	66	107	148						870	1145
			16										38	62	84	50	80	111							
		30	12													58	93	128							1068
			16													44	70	96							
F=1,600 Lbs. per Sq. In. E=1,600,000 V= Varies	Structural Square Edge Southern Pine; Select Coast Douglas Fir.	5	12	152	366														468	1124					
			16	114	275																				
		6	12	105	254	451	730												390	938	1668				
			16	79	191	338	548																		
		7	12	78	187	331	535	532	860										334	805	1426	2295			
			16	59	140	248	402	399	645																
		8	12	59	143	254	411	406	632										292	704	1252	2000			
			16	44	107	191	308	305	474																
		9	12		113	201	312	321	518	471	762	1050								625	1110	1780	2615		
			16		85	151	234	241	388	353	571	788													
		10	12		91	163	263	260	420	383	618	854								562	1000	1600	2355		
			16		68	122	197	195	315	287	464	640													
		11	12		75	134	216	216	348	314	508	702	436	705	972					510	907	1460	2130	2950	
			16		56	101	162	162	261	235	381	526	327	528	730										
		12	12		64	113	182	181	292	266	429	592	364	588	813					468	834	1333	1960	2690	
			16		48	85	136	136	219	200	322	444	273	441	610										
		14	12			83	134	133	215	195	315	435	268	434	600	353	570	788			714	1145	1680	2315	3040
			16			62	101	100	161	146	236	326	201	333	450	265	428	591							
		16	12			64	102	102	165	149	241	332	205	332	458	271	438	605			625	1004	1470	2025	2670
			16			48	77	77	124	112	181	249	154	249	344	203	329	454							
		18	12					80	130	118	191	264	163	263	363	215	348	480				890	1310	1800	2380
			16					60	98	89	143	198	122	197	272	161	261	360							
		20	12					65	106	96	154	207	132	212	293	173	280	387				800	1176	1620	2135
			16					49	80	72	116	155	99	159	220	130	210	290							
		22	12							79	128	176	109	176	243	143	231	319					1070	1475	1940
			16							59	96	132	82	132	182	107	173	239							
		24	12							66	107	148	91	148	204	120	195	269					980	1350	1780
			16							50	80	111	68	111	153	90	146	202							
		26	12										78	126	174	102	165	228						1250	1640
			16										59	95	130	77	124	171							
		28	12										67	109	150	89	143	198						1160	1530
			16										50	82	113	67	107	148							
		30	12													77	124	172							1422
			16													58	93	129							

D_{12} = Deflection for F = 1,200.
D_{16} = Deflection for F = 1,600.
D_P = Maximum deflection for joist. with plaster ceiling = 1/360 span.

DEFLECTION AND SHEAR

IN WOOD BEAMS

$E = 1{,}600{,}000$

DEFLECTION

Deflection in Inches For Various Depths of Sections

SPAN IN FEET	3⅝"			5⅝"			7½"			9½"			11½"			13½"			15½"			17½"			SPAN IN FEET
	D_{12}	D_{16}	D_P	D_{12}	D_{16}	D_P	D_{12}	D_{16}	D_P	D_{12}	D_{16}	D_P	D_{12}	D_{16}	D_P	D_{12}	D_{16}	D_P	D_{12}	D_{16}	D_P	D_{12}	D_{16}	D_P	
5	.155	.207	.166	.100	.133	.166																			5
6	.223	.298	.200	.144	.192	.200	.108	.144	.200																6
7	.304	.405	.233	.196	.261	.233	.147	.196	.233																7
8	.397	.530	.266	.256	.341	.266	.192	.256	.266	.151	.202	.266													8
9				.324	.432	.300	.243	.324	.300	.192	.256	.300	.158	.211	.300										9
10				.400	.533	.333	.300	.399	.333	.237	.315	.333	.196	.261	.333										10
11				.484	.645	.366	.363	.484	.366	.287	.382	.366	.236	.315	.366	.202	.269	.366							11
12				.576	.767	.400	.432	.576	.400	.341	.455	.400	.282	.375	.400	.240	.320	.400							12
13							.507	.675	.433	.400	.533	.433	.331	.440	.433	.282	.376	.433	.245	.327	.433				13
14							.588	.783	.466	.465	.619	.467	.384	.511	.466	.328	.436	.466	.285	.380	.466				14
15							.675	.899	.500	.533	.710	.500	.440	.586	.500	.376	.501	.500	.327	.436	.500	.289	.386	.500	15
16							.768	1.023	.533	.607	.808	.533	.501	.667	.533	.428	.570	.533	.371	.494	.533	.329	.440	.533	16
17										.685	.912	.566	.566	.753	.566	.483	.643	.566	.420	.559	.566	.371	.495	.566	17
18										.768	1.022	.600	.634	.844	.600	.540	.719	.600	.471	.627	.600	.417	.555	.600	18
19										.855	1.139	.633	.706	.941	.633	.602	.801	.633	.524	.698	.633	.464	.618	.633	19
20										.948	1.262	.666	.783	1.043	.666	.667	.889	.666	.581	.773	.666	.515	.685	.666	20
21													.863	1.149	.700	.736	.979	.700	.640	.853	.700	.568	.756	.700	21
22													.947	1.261	.733	.807	1.075	.733	.703	.935	.733	.623	.829	.733	22
23													1.036	1.379	.766	.882	1.174	.766	.769	1.023	.766	.681	.906	.766	23
24													1.127	1.501	.800	.961	1.279	.800	.837	1.114	.800	.740	.986	.800	24
25																1.043	1.388	.833	.907	1.208	.833	.804	1.070	.833	25
26																1.128	1.501	.866	.982	1.307	.866	.870	1.158	.866	26
27																1.216	1.619	.900	1.059	1.410	.900	.937	1.248	.900	27
28																1.308	1.741	.933	1.139	1.516	.933	1.009	1.343	.933	28
29																			1.222	1.627	.966	1.082	1.440	.966	29
30																			1.307	1.740	1.000	1.158	1.542	1.000	30

$$W = \frac{4\,bdv}{3}$$

W = Allowable load.
b = Width of beam.
d = Depth of beam.
v = Unit shear.

SHEAR

ALLOWABLE LOADS ON WOOD JOIST OR BEAMS AS LIMITED BY HORIZONTAL SHEAR

NOM. SIZE	ACTUAL SIZE	AREA SQ.IN.	Horizontal Shear, Lbs. Sq. In.						
			50	75	100	125	150	175	200
2x 4	1⅝x 3⅝	5.89	392	588	784	980	1176	1372	1568
4x 4	3⅝x 3⅝	13.14	876	1314	1752	2190	2628	3066	3504
2x 6	1⅝x 5⅝	9.14	610	915	1220	1525	1830	2135	2440
2½x 6	2⅛x 5⅝	11.95	797	1195	1593	1992	2390	2788	3186
3x 6	2⅝x 5⅝	14.77	984	1477	1969	2461	2954	3446	3937
4x 6	3⅝x 5⅝	20.39	1360	2040	2720	3400	4080	4760	5440
6x 6	5½x 5½	30.25	2016	3024	4032	5040	6048	7056	8064
2x 8	1⅝x 7½	12.19	813	1219	1625	2031	2437	2843	3249
2½x 8	2⅛x 7½	15.94	1013	1594	2125	2656	3188	3719	4250
3x 8	2⅝x 7½	19.69	1313	1969	2625	3281	3938	4594	5250
4x 8	3⅝x 7½	27.19	1813	2719	3625	4531	5438	6344	7250
6x 8	5½x 7½	41.25	2750	4125	5500	6875	8250	9625	11000
8x 8	7½x 7½	56.25	3750	5625	7500	9375	11250	13125	15000
2x10	1⅝x 9½	15.44	1029	1544	2058	2572	3087	3601	4116
2½x10	2⅛x 9½	20.19	1346	2019	2692	3365	4038	4711	5384
3x10	2⅝x 9½	24.94	1663	2494	3325	4156	4988	5819	6650
4x10	3⅝x 9½	34.44	2296	3444	4592	5740	6888	8036	9184
6x10	5½x 9½	52.25	3483	5225	6966	8707	10449	12190	13932
8x10	7½x 9½	71.25	4750	7125	9500	11875	14250	16625	19000
10x10	9½x 9½	90.25	6016	9024	12032	15040	18048	21056	24064
2x12	1⅝x11½	18.69	1246	1869	2492	3115	3738	4361	4984
2½x12	2⅛x11½	24.44	1630	2444	3259	4073	4888	5702	6517
3x12	2⅝x11½	30.19	2013	3019	4025	5031	6038	7044	8050
4x12	3⅝x11½	41.69	2780	4169	5559	6948	8338	9727	11117
6x12	5½x11½	63.25	4216	6324	8432	10540	12648	14756	16864
8x12	7½x11½	86.25	5750	8625	11500	14375	17250	20125	23000
10x12	9½x11½	109.25	7283	10925	14566	18207	21849	25490	29132
12x12	11½x11½	132.25	8816	13224	17632	22040	26448	30856	35264

NOM. SIZE	ACTUAL SIZE	AREA SQ.IN.	Horizontal Shear, Lbs. Sq. In.						
			50	75	100	125	150	175	200
2x14	1⅝x13½	21.94	1463	2194	2925	3656	4388	5119	5850
2½x14	2⅛x13½	28.69	1913	2869	3825	4781	5738	6694	7650
3x14	2⅝x13½	35.44	2363	3544	4725	5906	7088	8269	9450
4x14	3⅝x13½	48.94	3263	4894	6525	8156	9788	11419	13050
6x14	5½x13½	74.25	4950	7438	9900	12375	14875	17325	19800
8x14	7½x13½	101.25	6750	10125	13500	16875	20250	23625	27000
10x14	9½x13½	128.25	8550	12825	17100	21375	25650	29925	34200
12x14	11½x13½	155.25	10350	15525	20700	25875	31050	36225	41400
14x14	13½x13½	182.25	12150	18225	24300	30375	36450	42525	48600
2x16	1⅝x15½	25.19	1679	2519	3358	4198	5038	5877	6717
2½x16	2⅛x15½	32.94	2196	3294	4392	5490	6588	7686	8784
3x16	2⅝x15½	40.69	2713	4069	5425	6781	8138	9494	10850
4x16	3⅝x15½	56.19	3746	5619	7492	9365	11238	13111	14984
6x16	5½x15½	85.25	5683	8525	11366	14207	17049	19890	22732
8x16	7½x15½	116.25	7750	11625	15500	19375	23250	27125	31000
10x16	9½x15½	147.25	9817	14726	19634	24542	29451	34359	39268
12x16	11½x15½	178.25	11883	17825	23766	29707	35649	41590	47532
14x16	13½x15½	209.25	13950	20925	27900	34875	41850	48825	55800
16x16	15½x15½	240.25	16016	24024	32032	40040	48048	56056	64064
2x18	1⅝x17½	28.44	1896	2844	3792	4740	5688	6636	7584
2½x18	2⅛x17½	37.19	2479	3719	4958	6198	7438	8677	9917
3x18	2⅝x17½	45.94	3063	4594	6125	7656	9188	10719	12250
4x18	3⅝x17½	63.44	4229	6344	8458	10573	12688	14802	16917
6x18	5½x17½	96.25	6417	9626	12834	16042	19251	22459	25668
8x18	7½x17½	131.25	8750	13125	17500	21875	26250	30625	35000
10x18	9½x17½	166.25	11083	16625	22166	27707	33249	38790	44332
12x18	11½x17½	201.25	13417	20126	26834	33542	40251	46959	53668
14x18	13½x17½	236.25	15750	23625	31500	39375	47250	55125	63000
16x18	15½x17½	271.25	18083	27125	36166	45207	54249	63290	72332
18x18	17½x17½	306.25	20416	30624	40832	51040	61248	71456	81664

P = Safe load in pounds.
A = Area of Section, in^2.
S = Safe compressive unit stress.
E = Modulus of Elasticity.

WOOD COLUMNS

SAFE LOADS AND FIBER STRESSES

L = Unsupported length, inches.
d = Least dimension, inches.
K = Constant, for given species, grade, etc.; see tabular values.

SAFE LOADS IN KIPS

SIZE		AREA SQ. IN.	L/d	LENGTH FEET	FOR FIBER STRESSES GIVEN					
NOMINAL	ACTUAL				900	1000	1100	1200	1300	1400
6x6	5½x5½	30.25	17.5	8	25.64	28.12	30.43	32.67	34.60	41.75
			21.8	10	23.40	25.10	26.35	27.22	27.92	40.90
			26.2	12	19.18	19.36	19.36	19.36	19.36	19.36
			30.5	14	14.24	14.24	14.24	14.24	14.24	14.24
8x8	7½x7½	56.25	12.8	8	49.76	55.12	60.36	65.48	70.64	75.60
			16.0	10	48.54	53.44	58.16	62.78	66.90	70.88
			19.2	12	46.32	50.34	54.17	57.38	59.96	62.78
			22.4	14	42.52	45.56	47.59	48.60	49.00	49.00
			25.6	16	36.96	37.68	37.68	37.68	37.68	37.68
			28.8	18	29.70	29.70	29.70	29.70	29.70	29.70
			32.0	20	24.10	24.10	24.10	24.10	24.10	24.10
10x10	9½x9½	90.25	10.1	8	80.74	89.52	98.28	108.30	115.80	124.36
			12.6	10	80.00	88.44	96.93	105.04	113.58	121.48
			15.2	12	78.62	86.64	94.40	101.80	109.46	116.33
			17.7	14	76.36	83.48	90.25	96.38	102.42	107.76
			20.2	16	72.70	78.52	84.02	88.80	92.68	94.67
			22.7	18	67.82	71.30	74.64	76.88	76.52	76.52
			25.3	20	60.52	62.28	62.00	62.00	62.00	62.00
12x12	11½x11½	132.25	8.3	8	118.66	131.72	144.81	157.90	170.90	183.83
			10.4	10	118.20	131.06	143.89	156.64	169.34	181.84
			12.5	12	117.24	129.74	142.17	154.42	166.42	178.41
			14.6	14	115.70	127.76	139.39	150.76	161.60	172.59
			16.7	16	113.30	124.32	135.03	145.22	154.72	163.59
			18.8	18	109.50	119.68	128.68	137.28	144.42	150.63
			20.9	20	104.74	113.08	119.82	125.38	128.94	132.78
14x14	13½x13½	182.25	7.1	8	163.86	181.88	199.93	218.04	236.22	254.24
			8.9	10	163.36	181.34	199.38	217.16	235.02	252.78
			10.7	12	162.72	180.42	198.11	215.64	232.90	250.23
			12.4	14	161.56	178.96	196.10	213.02	229.34	246.04
			14.2	16	159.76	176.78	192.82	209.08	224.60	239.48
			16.0	18	157.14	173.14	188.26	203.38	216.78	229.64
			17.8	20	153.70	168.58	182.07	194.64	206.12	216.88
16x16	15½x15½	240.25	6.2	8	216.00	240.00	264.03	288.02	311.70	335.63
			7.7	10	215.78	239.52	263.31	287.14	311.08	334.67
			9.3	12	215.36	238.80	262.35	286.00	309.20	332.51
			10.8	14	214.50	237.84	260.91	283.98	306.70	329.38
			12.4	16	212.98	235.92	258.51	280.80	302.96	324.58
			14.0	18	211.04	233.04	254.67	276.20	297.34	316.89
			15.5	20	208.44	225.68	250.34	269.56	288.90	307.52
18x18	17½x17½	306.25	5.5	8	275.62	306.24	336.88	367.12	397.72	428.14
			6.9	10	275.34	305.64	336.26	366.40	396.94	427.22
			8.2	12	274.80	305.34	335.34	365.66	395.74	425.69
			9.6	14	274.24	304.42	334.12	363.82	393.74	423.24
			11.0	16	273.14	302.88	332.28	361.62	390.96	419.26
			12.3	18	271.76	301.04	329.53	357.94	386.18	413.74
			13.7	20	269.56	297.98	325.85	353.54	379.82	406.09

COMPRESSION UNIT STRESSES, #/□"

L/d	FOR FIBER STRESSES GIVEN					
	900	1000	1100	1200	1300	1400
5	900	1000	1100	1200	1300	1399
6	900	999	1099	1199	1297	1397
7	898	998	1098	1196	1296	1394
8	897	997	1096	1194	1294	1392
9	896	995	1093	1192	1290	1386
10	895	992	1090	1187	1283	1379
11	892	989	1085	1181	1275	1369
12	888	984	1078	1174	1265	1358
13	884	978	1071	1162	1252	1341
14	878	970	1060	1150	1235	1319
15	871	960	1047	1133	1216	1295
16	862	950	1034	1110	1190	1260
17	852	935	1012	1092	1164	1225
18	842	920	990	1062	1125	1176
19	828	900	968	1032	1079	1120
20	810	880	935	984	1027	1064
21	792	850	902	948	975	994
22	765	820	858	888	897	*905
23	738	790	814	828	*829	*829
24	711	750	759	*761	*761	*761
25	675	700	*701	*701	*701	*701
26	639	*649	*649	*649	*649	*649
27	600	*601	*601	*601	*601	*601
28	*559	*559	*559	*559	*559	*559
29	*521	*521	*521	*521	*521	*521
30	*487	*487	*487	*487	*487	*487

* Denotes value determined by Euler Formula.

VALUES OF K

E = 1,600,000

UNIT STRESS LBS. SQ. IN.	K	UNIT STRESS LBS. SQ. IN.	K
900	27.0	1300	22.5
1000	25.6	1400	21.7
1100	24.5	1500	21.0
1200	23.4	1600	20.3

Forest Products Laboratory formula is used where value of K does not exceed ratio L/d. Where L/d exceeds K, Eulers formula is used.

Forest Prod. Lab.:

$$\frac{P}{A} = S\left[1 - \frac{1}{3}\left(\frac{L}{Kd}\right)^4\right]$$

Euler:

$$\frac{P}{A} = \frac{.274E}{(L \div d)^2}$$

STRENGTH OF INTERMEDIATE COLUMNS

IN PERCENTAGE OF STRENGTH OF SHORT COLS.

Percentages given below are values of Forest Products formula. When L/d exceeds K, design by Euler Formula. For use in designing round columns, compute side of equivalent square column and proceed as for latter.

K	Ratio of Length to Least Dimension (L÷d)																	
	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
21	96	95	93	91	89	86	82	78	73	67								
22	97	96	95	93	91	88	85	81	77	72	67							
23	98	97	95	94	92	90	87	84	81	77	72	67						
24	98	97	96	95	93	92	89	87	84	80	76	72	67					
25	98	98	97	96	94	93	91	89	86	83	80	76	72	67				
26	99	98	97	96	95	93	92	91	89	86	83	80	76	72	67			
27	99	98	98	97	96	95	93	92	90	88	85	82	79	74	71	67		
28	99	99	98	97	96	95	94	93	91	89	87	85	82	79	75	71	67	
29	99	99	98	98	97	96	95	94	92	91	89	87	84	82	79	75	71	67

I = Moment of Inertia.
S = Section Modulus.
Above figured about Axis I-I,
except for plank floors.

PROPERTIES AND MOMENT VALUES
OF TIMBER SECTIONS

SIZE		AREA NET SQ. IN.	Axis 1-1		BENDING MOMENT. KIP FT. LBS., FOR FIBER STRESSES IN LBS. SQ. IN. AS GIVEN										
NOMINAL	ACTUAL		I	S	800	900	1000	1100	1200	1300	1400	1500	1600	1800	2000
2x 4	1⅝x 3⅝	5.89	6.45	3.56	.24	.27	.30	.33	.36	.39	.42	.45	.48	.54	.59
4x 4	3⅝x 3⅝	13.14	14.39	7.94	.53	.60	.66	.73	.79	86	.93	.99	1.06	1.19	1.32
2x 6	1⅝x 5⅝	9.14	24.10	8.57	.57	.64	.71	.79	.86	93	1.00	1.07	1.14	1.29	1.43
2½x 6	2⅛x 5⅝	11.95	31.52	11.21	.75	.84	.94	1.03	1.12	1.22	1.31	1.40	1.50	1.68	1.87
3x 6	2⅝x 5⅝	14.77	38.93	13.84	.92	1.04	1.15	1.27	1.38	1.50	1.61	1.73	1.84	2.08	2.30
4x 6	3⅝x 5⅝	20.39	53.76	19.12	1.28	1.44	1.59	1.75	1.91	2.07	2.23	2.39	2.55	2.87	3.19
6x 6	5½x 5½	30.25	76.25	27.73	1.85	2.08	2.31	2.54	2.77	3.00	3.24	3.47	3.70	4.16	4.62
2x 8	1⅝x 7½	12.19	57.13	15.23	1.02	1.14	1.27	1.40	1.52	1.65	1.78	1.90	2.03	2.28	2.54
2½x 8	2⅛x 7½	15.94	74.71	19.92	1.33	1.49	1.66	1.83	1.99	2.16	2.32	2.49	2.66	2.99	3.32
3x 8	2⅝x 7½	19.69	92.29	24.61	1.64	1.85	2.05	2.26	2.46	2.67	2.87	3.08	3.28	3.69	4.10
4x 8	3⅝x 7½	27.19	127.44	33.98	2.27	2.55	2.83	3.11	3.40	3.68	3.96	4.25	4.53	5.10	5.66
6x 8	5½x 7½	41.25	193.36	51.56	3.44	3.87	4.30	4.73	5.16	5.59	6.02	6.45	6.88	7.74	8.59
8x 8	7½x 7½	56.25	263.67	70.31	4.69	5.27	5.86	6.45	7.03	7.62	8.20	8.79	9.37	10.55	11.72
2x10	1⅝x 9½	15.44	116.10	24.44	1.63	1.83	2.04	2.24	2.44	2.65	2.85	3.06	3.26	3.67	4.07
2½x10	2⅛x 9½	20.19	151.83	31.96	2.13	2.40	2.66	2.93	3.20	3.46	3.73	3.99	4.26	4.79	5.33
3x10	2⅝x 9½	24.94	187.55	39.48	2.63	2.96	3.29	3.62	3.95	4.28	4.61	4.94	5.26	5.92	6.58
4x10	3⅝x 9½	34.44	259.00	54.53	3.64	4.09	4.54	5.00	5.45	5.91	6.36	6.82	7.27	8.18	9.09
6x10	5½x 9½	52.25	392.96	82.73	5.52	6.20	6.89	7.58	8.27	8.96	9.65	10.34	11.03	12.41	13.79
8x10	7½x 9½	71.25	535.86	112.81	7.52	8.46	9.40	10.34	11.28	12.22	13.16	14.10	15.04	16.92	18.80
10x10	9½x 9½	90.25	678.75	142.89	9.53	10.72	11.91	13.10	14.29	15.48	16.67	17.86	19.05	21.43	23.82
2x12	1⅝x11½	18.69	205.95	35.82	2.39	2.69	2.99	3.28	3.58	3.88	4.18	4.48	4.78	5.37	5.97
2½x12	2⅛x11½	24.44	269.32	46.84	3.12	3.51	3.90	4.29	4.68	5.07	5.46	5.85	6.25	7.03	7.81
3x12	2⅝x11½	30.19	332.69	57.86	3.86	4.34	4.82	5.30	5.79	6.27	6.75	7.23	7.71	8.68	9.64
4x12	3⅝x11½	41.69	459.43	79.90	5.33	5.99	6.66	7.32	7.99	8.66	9.32	9.99	10.65	11.98	13.32
6x12	5½x11½	63.25	697.07	121.23	8.08	9.09	10.10	11.11	12.12	13.13	14.14	15.16	16.17	18.19	20.21
8x12	7½x11½	86.25	950.55	165.31	11.02	12.40	13.78	15.15	16.53	17.91	19.29	20.66	22.04	24.80	27.55
10x12	9½x11½	109.25	1204.03	209.39	13.96	15.70	17.45	19.20	20.94	22.69	24.43	26.18	27.92	31.41	34.90
12x12	11½x11½	132.25	1457.51	253.48	16.90	19.01	21.12	23.24	25.35	27.46	29.57	31.69	33.80	38.02	42.25
2x14	1⅝x13½	21.94	333.18	49.36	3.29	3.70	4.11	4.52	4.94	5.35	5.76	6.17	6.58	7.40	8.23
2½x14	2⅛x13½	28.69	435.69	64.55	4.30	4.84	5.38	5.92	6.46	6.99	7.53	8.07	8.61	9.68	10.76
3x14	2⅝x13½	35.44	538.21	79.73	5.32	5.98	6.64	7.31	7.97	8.64	9.30	9.97	10.63	11.96	13.29
4x14	3⅝x13½	48.94	743.24	110.11	7.34	8.26	9.18	10.09	11.01	11.93	12.85	13.76	14.68	16.52	18.35
6x14	5½x13½	74.25	1127.67	167.10	11.14	12.53	13.92	15.31	16.71	18.10	19.49	20.88	22.28	25.06	27.84
8x14	7½x13½	101.25	1537.73	227.81	15.19	17.09	18.98	20.88	22.78	24.68	26.58	28.48	30.37	34.17	37.97
10x14	9½x13½	128.25	1947.80	288.56	19.24	21.64	24.05	26.45	28.86	31.26	33.67	36.07	38.48	43.29	48.09
12x14	11½x13½	155.25	2357.86	349.31	23.29	26.20	29.11	32.02	34.93	37.84	40.75	43.66	46.57	52.40	58.22
14x14	13½x13½	182.25	2767.92	410.06	27.34	30.75	34.17	37.59	41.01	44.42	47.84	51.26	54.68	61.51	68.34
2x16	1⅝x15½	25.19	504.27	65.07	4.34	4.88	5.42	5.97	6.51	7.05	7.59	8.14	8.68	9.76	10.85
2½x16	2⅛x15½	32.94	659.44	85.09	5.67	6.38	7.09	7.80	8.51	9.22	9.93	10.64	11.35	12.76	14.18
3x16	2⅝x15½	40.69	814.60	105.11	7.01	7.88	8.76	9.64	10.51	11.39	12.26	13.14	14.01	15.77	17.52
4x16	3⅝x15½	56.19	1124.92	145.15	9.68	10.89	12.10	13.31	14.51	15.72	16.93	18.14	19.35	21.77	24.19
6x16	5½x15½	85.25	1706.78	220.23	14.68	16.52	18.35	20.19	22.02	23.86	25.69	27.53	29.37	33.04	36.71
8x16	7½x15½	116.25	2327.42	300.31	20.02	22.52	25.03	27.53	30.03	32.53	35.04	37.54	40.04	45.05	50.05
10x16	9½x15½	147.25	2948.07	380.39	25.36	28.53	31.70	34.87	38.04	41.21	44.38	47.55	50.72	57.06	63.40
12x16	11½x15½	178.25	3568.71	460.48	30.70	34.54	38.37	42.21	46.05	49.89	53.72	57.56	61.40	69.07	76.75
14x16	13½x15½	209.25	4189.36	540.56	36.04	40.54	45.05	49.55	54.06	58.56	63.07	67.57	72.08	81.09	90.09
16x16	15½x15½	240.25	4810.00	620.65	41.38	46.55	51.72	56.89	62.06	67.24	72.41	77.58	82.75	93.10	103.44
2x18	1⅝x17½	28.44	725.75	82.94	5.53	6.22	6.91	7.60	8.29	8.99	9.68	10.37	11.06	12.44	13.82
2½x18	2⅛x17½	37.19	949.06	108.46	7.23	8.13	9.04	9.94	10.85	11.75	12.65	13.56	14.46	16.27	18.08
3x18	2⅝x17½	45.94	1172.36	133.98	8.93	10.05	11.17	12.28	13.40	14.51	15.63	16.75	17.86	20.10	22.33
4x18	3⅝x17½	63.44	1618.98	185.03	12.34	13.88	15.42	16.96	18.50	20.04	21.59	23.13	24.67	27.75	30.84
6x18	5½x17½	96.25	2456.38	280.73	18.72	21.05	23.39	25.73	28.07	30.41	32.75	35.09	37.43	42.11	46.79
8x18	7½x17½	131.25	3349.61	382.81	25.52	28.71	31.90	35.09	38.28	41.47	44.66	47.85	51.04	57.42	63.80
10x18	9½x17½	166.25	4242.84	484.89	32.33	36.37	40.41	44.45	48.49	52.53	56.57	60.61	64.65	72.73	80.82
12x18	11½x17½	201.25	5136.07	586.98	39.13	44.02	48.92	53.81	58.70	63.59	68.48	73.37	78.26	88.05	97.83
14x18	13½x17½	236.25	6029.29	689.06	45.94	51.68	57.42	63.16	68.91	74.65	80.39	86.13	91.88	103.36	114.84
16x18	15½x17½	271.25	6922.53	791.14	52.74	59.34	65.93	72.52	79.12	85.71	92.30	98.89	105.49	118.67	131.86
18x18	17½x17½	306.25	7815.76	893.23	59.55	66.99	74.44	81.88	89.32	96.77	104.21	111.65	119.10	133.99	148.87

Plank Floors—12″ Wide—Matched and Dressed

1	⅞	10.50	0.67	1.53	.10	.11	.13	.14	.15	.17	.18	.19	.20	.23	.26
1½	1¼	15.00	1.95	3.13	.21	.23	.26	.29	.31	.34	.37	.39	.42	.47	.52
2	1⅝	19.50	4.29	5.28	.35	.40	.44	.48	.53	.57	.62	.66	.70	.79	.88
2½	2⅛	25.50	9.59	9.03	.60	.68	.75	.83	.90	.98	1.05	1.13	1.20	1.35	1.51
3	2⅝	31.50	18.09	13.78	.92	1.03	1.15	1.26	1.38	1.49	1.61	1.72	1.84	2.07	2.30
4	3⅝	43.50	47.63	26.28	1.75	1.97	2.19	2.41	2.63	2.85	3.07	3.29	3.50	3.94	4.38

PART VI

REFERENCE DATA

FRACTIONAL POWERS AND ROOTS

FRAC.	1/64	SQUARE	CUBE	SQUARE ROOT	CUBE ROOT
	1	.00024414	.00000381	0.12500	0.25
$\frac{1}{32}$	2	.00097656	.00003052	0.17678	0.3150
	3	.00219727	.00010300	0.21651	0.3606
$\frac{1}{16}$	4	.00390625	.00024414	0.25000	0.3969
	5	.00610352	.00047684	0.27951	0.4275
$\frac{3}{32}$	6	.00878906	.00082397	0.30618	0.4543
	7	.01196289	.00130844	0.33072	0.4782
⅛	8	.0156250	.0019531	0.35356	0.50
	9	.01977539	.00278091	0.37500	0.5201
$\frac{5}{32}$	10	.02441406	.00381470	0.39529	0.5386
	11	.02954102	.00507736	0.41458	0.5560
$\frac{3}{16}$	12	.03515625	.00659180	0.43301	0.5724
	13	.04125977	.00838089	0.45069	0.5879
$\frac{7}{32}$	14	.04785156	.01046753	0.46771	0.6025
	15	.05493164	.01287460	0.48412	0.6165
¼	16	.0625	.015625	0.50	0.6300
	17	.07055664	.01874161	0.51539	0.6352
$\frac{9}{32}$	18	.07910156	.02224731	0.53033	0.6552
	19	.08813477	.02616501	0.54487	0.6671
$\frac{5}{16}$	20	.09765625	.03051758	0.55902	0.6786
	21	.10766602	.03532791	0.57283	0.6897
$\frac{11}{32}$	22	.11816406	.04061890	0.58599	0.7005
	23	.12915039	.04641342	0.59948	0.7110
⅜	24	.14062500	.05273438	0.61238	0.7211
	25	.15258789	.05960464	0.62500	0.7310
$\frac{13}{32}$	26	.16503906	.06704712	0.63738	0.7406
	27	.17797851	.07508469	0.64952	0.7500
$\frac{7}{16}$	28	.19140625	.08374023	0.66144	0.7592
	29	.20532227	.09303665	0.67314	0.7681
$\frac{15}{32}$	30	.21972656	.10299683	0.68472	0.7768
	31	.23461914	.11364365	0.69597	0.7854
½	32	.25	.125	0.70710	0.7937
	33	.26586914	.13708876	0.71807	0.8019
$\frac{17}{32}$	34	.28222656	.14993286	0.72887	0.8099
	35	.29907227	.16355515	0.73951	0.8178
$\frac{9}{16}$	36	.31640625	.17797852	0.75000	0.8255
	37	.33422852	.19322586	0.76034	0.8331
$\frac{19}{32}$	38	.35253906	.20932007	0.77055	0.8405
	39	.37133789	.22628403	0.78006	0.8478
⅝	40	.390625	.24414063	0.79055	0.8550
	41	.41040039	.26291275	0.80039	0.8621
$\frac{21}{32}$	42	.43066406	.28262329	0.81009	0.8690
	43	.45141602	.30329514	0.81968	0.8759
$\frac{11}{16}$	44	.47265625	.32495117	0.82916	0.8826
	45	.49438477	.34761429	0.83852	0.8892
$\frac{23}{32}$	46	.51660156	.37130737	0.84779	0.8958
	47	.53930664	.39605331	0.85696	0.9022
¾	48	.5625	.421875	0.8660	0.9086
	49	.58618164	.44879532	0.87500	0.9148
$\frac{25}{32}$	50	.61035156	.47683716	0.88378	0.9210
	51	.63500977	.50602341	0.89268	0.9271
$\frac{13}{16}$	52	.66015625	.53637695	0.90139	0.9331
	53	.68579102	.56792069	0.91001	0.9391
$\frac{27}{32}$	54	.71191406	.60067749	0.91855	0.9450
	55	.73852539	.63467026	0.92699	0.9507
⅞	56	.765625	.66992188	0.93539	0.9565
	57	.79321289	.70645523	0.94375	0.9621
$\frac{29}{32}$	58	.82128906	.74429321	0.95197	0.9677
	59	.84985352	.78345871	0.96014	0.9733
$\frac{15}{16}$	60	.87890625	.82397461	0.96825	0.9787
	61	.90844727	.86586380	0.97628	0.9841
$\frac{31}{32}$	62	.93847656	.90914917	0.98425	0.9895
	63	.96899414	.95385361	0.99215	0.9948
1	64	1.0	1.0	1.0	1.0

.01

.49

FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter	
							Circum.	Area
.01	.0001	.000001	0.1000	0.2154	$\bar{2}$.00000	100000.000	.03142	.000079
.02	.0004	.000008	0.1414	0.2714	$\bar{2}$.30103	50000.000	.06283	.000314
.03	.0009	.000027	0.1732	0.3107	$\bar{2}$.47712	33333.333	.09425	.000707
.04	.0016	.000064	0.2000	0.3420	$\bar{2}$.60206	25000.000	.12566	.001257
.05	.0025	.000125	0.2236	0.3684	$\bar{2}$.69897	20000.000	.15708	.001964
.06	.0036	.000216	0.2449	0.3915	$\bar{2}$.77815	16666.667	.18850	.002827
.07	.0049	.000343	0.2646	0.4121	$\bar{2}$.84510	14285.714	.21991	.003849
.08	.0064	.000512	0.2828	0.4309	$\bar{2}$.90309	12500.000	.25133	.005027
.09	.0081	.000729	0.3000	0.4481	$\bar{2}$.95424	11111.111	.28274	.006362
.10	.0100	.001000	0.3162	0.4642	$\bar{1}$.00000	10000.000	.31416	.007854
.11	.0121	.001331	0.3317	0.4791	$\bar{1}$.04139	9090.909	.34558	.009503
.12	.0144	.001728	0.3464	0.4932	$\bar{1}$.07918	8333.333	.37699	.011310
.13	.0169	.002197	0.3606	0.5066	$\bar{1}$.11394	7692.308	.40841	.013273
.14	.0196	.002744	0.3742	0.5192	$\bar{1}$.14613	7142.857	.43982	.015394
.15	.0225	.003375	0.3873	0.5313	$\bar{1}$.17609	6666.667	.47124	.017672
.16	.0256	.004096	0.4000	0.5429	$\bar{1}$.20412	6250.000	.50265	.020106
.17	.0289	.004913	0.4123	0.5540	$\bar{1}$.23045	5882.353	.53407	.022698
.18	.0324	.005832	0.4243	0.5646	$\bar{1}$.25527	5555.556	.56549	.025447
.19	.0361	.006859	0.4359	0.5749	$\bar{1}$.27875	5263.158	.59690	.028353
.20	.0400	.008000	0.4472	0.5848	$\bar{1}$.30103	5000.000	.62832	.031416
.21	.0441	.009261	0.4583	0.5944	$\bar{1}$.32222	4761.905	.65973	.034636
.22	.0484	.010648	0.4690	0.6037	$\bar{1}$.34242	4545.455	.69115	.038013
.23	.0529	.012167	0.4796	0.6127	$\bar{1}$.36173	4347.826	.72257	.041548
.24	.0576	.013824	0.4899	0.6214	$\bar{1}$.38021	4166.667	.75398	.045239
.25	.0625	.015625	0.5000	0.6300	$\bar{1}$.39794	4000.000	.78540	.049087
.26	.0676	.017576	0.5099	0.6383	$\bar{1}$.41497	3846.154	.81681	.053093
.27	.0729	.019683	0.5196	0.6463	$\bar{1}$.43136	3703.704	.84823	.057256
.28	.0784	.021952	0.5292	0.6542	$\bar{1}$.44716	3571.429	.87965	061575
.29	.0841	.024389	0.5385	0.6619	$\bar{1}$.46240	3448.276	.91106	.066052
.30	.0900	.027000	0.5477	0.6694	$\bar{1}$.47712	3333.333	.94248	.070686
.31	.0961	.029791	0.5568	0.6768	$\bar{1}$.49136	3225.807	.97389	.075477
.32	.1024	.032768	0.5657	0.6840	$\bar{1}$.50515	3125.000	1.00531	.080425
.33	.1089	.035937	0.5745	0.6910	$\bar{1}$.51851	3030.303	1.03673	.085530
.34	.1156	.039304	0.5831	0.6980	$\bar{1}$.53148	2941.177	1.06814	.090792
.35	.1225	.042875	0.5916	0.7047	$\bar{1}$.54407	2857.143	1.09956	.096211
.36	.1296	.046656	0.6000	0.7114	$\bar{1}$.55630	2777.778	1.13097	.101788
.37	.1369	.050653	0.6083	0.7179	$\bar{1}$.56820	2702.703	1.16239	.107521
.38	.1444	.054872	0.6164	0.7243	$\bar{1}$.57978	2631.579	1.19381	.113411
.39	.1521	.059319	0.6245	0.7306	$\bar{1}$.59106	2564.103	1.22522	.119459
.40	.1600	.064000	0.6325	0.7368	$\bar{1}$.60206	2500.000	1.2566	.125664
.41	.1681	.068921	0.6403	0.7429	$\bar{1}$.61278	2439.024	1.2881	.132025
.42	.1764	.074088	0.6481	0.7489	$\bar{1}$.62325	2380.952	1.3195	.138544
.43	.1849	.079507	0.6557	0.7548	$\bar{1}$.63347	2325.581	1.3509	.145220
.44	.1936	.085184	0.6633	0.7606	$\bar{1}$.64345	2272.727	1.3823	.152053
.45	.2025	.091125	0.6708	0.7663	$\bar{1}$.65321	2222.222	1.4137	.159043
.46	.2116	.097336	0.6782	0.7719	$\bar{1}$.66276	2173.913	1.4451	.166190
.47	.2209	.103823	0.6856	0.7775	$\bar{1}$.67210	2127.660	1.4765	.173494
.48	.2304	.110592	0.6928	0.7830	$\bar{1}$.68124	2083.333	1.5080	.180956
.49	.2401	.117649	0.7000	0.7884	$\bar{1}$.69020	2040.816	1.5394	.188574

FUNCTIONS OF NUMBERS

.50

.99

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter	
							Circum.	Area
.50	.2500	.125000	0.7071	0.7937	$\bar{1}$.69897	2000.000	1.5708	.19635
.51	.2601	.132651	0.7141	0.7990	$\bar{1}$.70757	1960.784	1.6022	.20428
.52	.2704	.140608	0.7211	0.8041	$\bar{1}$.71600	1923.077	1.6336	.21237
.53	.2809	.148877	0.7280	0.8093	$\bar{1}$.72428	1886.793	1.6650	.22062
.54	.2916	.157464	0.7348	0.8143	$\bar{1}$.73239	1851.852	1.6965	.22902
.55	.3025	.166375	0.7416	0.8193	$\bar{1}$.74036	1818.182	1.7279	.23758
.56	.3136	.175616	0.7483	0.8243	$\bar{1}$.74819	1785.714	1.7593	.24630
.57	.3249	.185193	0.7550	0.8291	$\bar{1}$.75587	1754.386	1.7907	.25518
.58	.3364	.195112	0.7616	0.8340	$\bar{1}$.76343	1724.138	1.8221	.26401
.59	.3481	.205379	0.7681	0.8387	$\bar{1}$.77085	1694.915	1.8535	.27340
.60	.3600	.216000	0.7746	0.8434	$\bar{1}$.77815	1666.667	1.8850	.28274
.61	.3721	.226981	0.7810	0.8481	$\bar{1}$.78533	1639.344	1.9164	.29225
.62	.3844	.238328	0.7874	0.8527	$\bar{1}$.79239	1612.903	1.9478	.30191
.63	.3969	.250047	0.7937	0.8573	$\bar{1}$.79934	1587.302	1.9792	.31173
.64	.4096	.262144	0.8000	0.8618	$\bar{1}$.80618	1562.500	2.0106	.32170
.65	.4225	.274625	0.8062	0.8662	$\bar{1}$.81291	1538.462	2.0420	.33183
.66	.4356	.287496	0.8124	0.8707	$\bar{1}$.81954	1515.152	2.0735	.34212
.67	.4489	.300763	0.8185	0.8750	$\bar{1}$.82607	1492.537	2.1049	.35257
.68	.4624	.314432	0.8246	0.8794	$\bar{1}$.83251	1470.588	2.1363	.36317
.69	.4761	.328509	0.8307	0.8837	$\bar{1}$.83885	1449.275	2.1677	.37393
.70	.4900	.343000	0.8367	0.8879	$\bar{1}$.84510	1428.571	2.1991	.38485
.71	.5041	.357911	0.8426	0.8921	$\bar{1}$.85126	1408.451	2.2305	.39592
.72	.5184	.373248	0.8485	0.8963	$\bar{1}$.85733	1388.889	2.2620	.40715
.73	.5329	.389017	0.8544	0.9004	$\bar{1}$.86332	1369.863	2.2934	.41854
.74	.5476	.405224	0.8602	0.9045	$\bar{1}$.86923	1351.351	2.3248	.43008
.75	.5625	.421875	0.8660	0.9086	$\bar{1}$.87506	1333.333	2.3562	.44179
.76	.5776	.438976	0.8718	0.9126	$\bar{1}$.88081	1315.790	2.3876	.45365
.77	.5929	.456533	0.8775	0.9166	$\bar{1}$.88649	1298.701	2.4190	.46566
.78	.6084	.474552	0.8832	0.9205	$\bar{1}$.89209	1282.051	2.4504	.47784
.79	.6241	.493039	0.8888	0.9244	$\bar{1}$.89763	1265.823	2.4819	.49017
.80	.6400	.512000	0.8944	0.9283	$\bar{1}$.90309	1250.000	2.5133	.50266
.81	.6561	.531441	0.9000	0.9322	$\bar{1}$.90849	1234.568	2.5447	.51530
.82	.6724	.551368	0.9055	0.9360	$\bar{1}$.91381	1219.512	2.5761	.52810
.83	.6889	.571787	0.9110	0.9398	$\bar{1}$.91908	1204.819	2.6075	.54106
.84	.7056	.592704	0.9165	0.9435	$\bar{1}$.92428	1190.476	2.6389	.55418
.85	.7225	.614125	0.9220	0.9473	$\bar{1}$.92942	1176.471	2.6704	.56745
.86	.7396	.636056	0.9274	0.9510	$\bar{1}$.93450	1162.791	2.7018	.58088
.87	.7569	.658503	0.9327	0.9546	$\bar{1}$.93952	1149.425	2.7332	.59447
.88	.7744	.681472	0.9381	0.9583	$\bar{1}$.94448	1136.364	2.7646	.60821
.89	.7921	.704969	0.9434	0.9619	$\bar{1}$.94939	1123.596	2.7960	.62211
.90	.8100	.729000	0.9487	0.9655	$\bar{1}$.95424	1111.111	2.8274	.63617
.91	.8281	.753571	0.9539	0.9691	$\bar{1}$.95904	1098.901	2.8589	.65039
.92	.8464	.778688	0.9592	0.9726	$\bar{1}$.96379	1086.957	2.8903	.66476
.93	.8649	.804357	0.9644	0.9761	$\bar{1}$.96848	1075.269	2.9217	.67929
.94	.8836	.830584	0.9695	0.9796	$\bar{1}$.97313	1063.830	2.9531	.69398
.95	.9025	.857375	0.9747	0.9830	$\bar{1}$.97772	1052.632	2.9845	.70882
.96	.9216	.884736	0.9798	0.9865	$\bar{1}$.98227	1041.667	3.0159	.72382
.97	.9409	.912673	0.9849	0.9899	$\bar{1}$.98677	1030.928	3.0473	.73898
.98	.9604	.941192	0.9899	0.9933	$\bar{1}$.99123	1020.408	3.0788	.75430
.99	.9801	.970299	0.9950	0.9967	$\bar{1}$.99564	1010.101	3.1102	.76977

1

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FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No = Diameter	
							Circum.	Area
1	1	1	1.0000	1.0000	0.00000	1000.000	3.142	0.7854
2	4	8	1.4142	1.2599	0.30103	500.000	6.283	3.1416
3	9	27	1.7321	1.4422	0.47712	333.333	9.425	7.0686
4	16	64	2.0000	1.5874	0.60206	250.000	12.566	12.5664
5	25	125	2.2361	1.7100	0.69897	200.000	15.708	19.6350
6	36	216	2.4495	1.8171	0.77815	166.667	18.850	28.2743
7	49	343	2.6458	1.9129	0.84510	142.857	21.991	38.4845
8	64	512	2.8284	2.0000	0.90309	125.000	25.133	50.2655
9	81	729	3.0000	2.0801	0.95424	111.111	28.274	63.6173
10	100	1000	3.1623	2.1544	1.00000	100.000	31.416	78.5398
11	121	1331	3.3166	2.2240	1.04139	90.9091	34.558	95.0332
12	144	1728	3.4641	2.2894	1.07918	83.3333	37.699	113.097
13	169	2197	3.6056	2.3513	1.11394	76.9231	40.841	132.732
14	196	2744	3.7417	2.4101	1.14613	71.4286	43.982	153.938
15	225	3375	3.8730	2.4662	1.17609	66.6667	47.124	176.715
16	256	4096	4.0000	2.5198	1.20412	62.5000	50.265	201.062
17	289	4913	4.1231	2.5713	1.23045	58.8235	53.407	226.980
18	324	5832	4.2426	2.6207	1.25527	55.5556	56.549	254.469
19	361	6859	4.3589	2.6684	1.27875	52.6316	59.690	283.529
20	400	8000	4.4721	2.7144	1.30103	50.0000	62.832	314.159
21	441	9261	4.5826	2.7589	1.32222	47.6190	65.973	346.361
22	484	10648	4.6904	2.8020	1.34242	45.4545	69.115	380.133
23	529	12167	4.7958	2.8439	1.36173	43.4783	72.257	415.476
24	576	13824	4.8990	2.8845	1.38021	41.6667	75.398	452.389
25	625	15625	5.0000	2.9240	1.39794	40.0000	78.540	490.874
26	676	17576	5.0990	2.9625	1.41497	38.4615	81.681	530.929
27	729	19683	5.1962	3.0000	1.43136	37.0370	84.823	572.555
28	784	21952	5.2915	3.0366	1.44716	35.7143	87.965	615.752
29	841	24389	5.3852	3.0723	1.46240	34.4828	91.106	660.520
30	900	27000	5.4772	3.1072	1.47712	33.3333	94.248	706.858
31	961	29791	5.5678	3.1414	1.49136	32.2581	97.389	754.768
32	1024	32768	5.6569	3.1748	1.50515	31.2500	100.531	804.248
33	1089	35937	5.7446	3.2075	1.51851	30.3030	103.673	855.299
34	1156	39304	5.8310	3.2396	1.53148	29.4118	106.814	907.920
35	1225	42875	5.9161	3.2711	1.54407	28.5714	109.956	962.113
36	1296	46656	6.0000	3.3019	1.55630	27.7778	113.097	1017.88
37	1369	50653	6.0828	3.3322	1.56820	27.0270	116.239	1075.21
38	1444	54872	6.1644	3.3620	1.57978	26.3158	119.381	1134.11
39	1521	59319	6.2450	3.3912	1.59106	25.6410	122.522	1194.59
40	1600	64000	6.3246	3.4200	1.60206	25.0000	125.66	1256.64
41	1681	68921	6.4031	3.4482	1.61278	24.3902	128.81	1320.25
42	1764	74088	6.4807	3.4760	1.62325	23.8095	131.95	1385.44
43	1849	79507	6.5574	3.5034	1.63347	23.2558	135.09	1452.20
44	1936	85184	6.6332	3.5303	1.64345	22.7273	138.23	1520.53
45	2025	91125	6.7082	3.5569	1.65321	22.2222	141.37	1590.43
46	2116	97336	6.7823	3.5830	1.66276	21.7391	144.51	1661.90
47	2209	103823	6.8557	3.6088	1.67210	21.2766	147.65	1734.94
48	2304	110592	6.9282	3.6342	1.68124	20.8333	150.80	1809.56
49	2401	117649	7.0000	3.6593	1.69020	20.4082	153.94	1885.74

FUNCTIONS OF NUMBERS

50
99

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter	
							Circum.	Area
50	2500	125000	7.0711	3.6840	1.69897	20.0000	157.08	1963.50
51	2601	132651	7.1414	3.7084	1.70757	19.6078	160.22	2042.82
52	2704	140608	7.2111	3.7325	1.71600	19.2308	163.36	2123.72
53	2809	148877	7.2801	3.7563	1.72428	18.8679	166.50	2206.18
54	2916	157464	7.3485	3.7798	1.73239	18.5185	169.65	2290.22
55	3025	166375	7.4162	3.8030	1.74036	18.1818	172.79	2375.83
56	3136	175616	7.4833	3.8259	1.74819	17.8571	175.93	2463.01
57	3249	185193	7.5498	3.8485	1.75587	17.5439	179.07	2551.76
58	3364	195112	7.6158	3.8709	1.76343	17.2414	182.21	2642.08
59	3481	205379	7.6811	3.8930	1.77085	16.9492	185.35	2733.97
60	3600	216000	7.7460	3.9149	1.77815	16.6667	188.50	2827.43
61	3721	226981	7.8102	3.9365	1.78533	16.3934	191.64	2922.47
62	3844	238328	7.8740	3.9579	1.79239	16.1290	194.78	3019.07
63	3969	250047	7.9373	3.9791	1.79934	15.8730	197.92	3117.25
64	4096	262144	8.0000	4.0000	1.80618	15.6250	201.06	3216.99
65	4225	274625	8.0623	4.0207	1.81291	15.3846	204.20	3318.31
66	4356	287496	8.1240	4.0412	1.81954	15.1515	207.35	3421.19
67	4489	300763	8.1854	4.0615	1.82607	14.9254	210.49	3525.65
68	4624	314432	8.2462	4.0817	1.83251	14.7059	213.63	3631.68
69	4761	328509	8.3066	4.1016	1.83885	14.4928	216.77	3739.28
70	4900	343000	8.3666	4.1213	1.84510	14.2857	219.91	3848.45
71	5041	357911	8.4261	4.1408	1.85126	14.0845	223.05	3959.19
72	5184	373248	8.4853	4.1602	1.85733	13.8889	226.19	4071.50
73	5329	389017	8.5440	4.1793	1.86332	13.6986	229.34	4185.39
74	5476	405224	8.6023	4.1983	1.86923	13.5135	232.48	4300.84
75	5625	421875	8.6603	4.2172	1.87506	13.3333	235.62	4417.86
76	5776	438976	8.7178	4.2358	1.88081	13.1579	238.76	4536.46
77	5929	456533	8.7750	4.2543	1.88649	12.9870	241.90	4656.63
78	6084	474552	8.8318	4.2727	1.89209	12.8205	245.04	4778.36
79	6241	493039	8.8882	4.2908	1.89763	12.6582	248.19	4901.67
80	6400	512000	8.9443	4.3089	1.90309	12.5000	251.33	5026.55
81	6561	531441	9.0000	4.3267	1.90849	12.3457	254.47	5153.00
82	6724	551368	9.0554	4.3445	1.91381	12.1951	257.61	5281.02
83	6889	571787	9.1104	4.3621	1.91908	12.0482	260.75	5410.61
84	7056	592704	9.1652	4.3795	1.92428	11.9048	263.89	5541.77
85	7225	614125	9.2195	4.3968	1.92942	11.7647	267.04	5674.50
86	7396	636056	9.2736	4.4140	1.93450	11.6279	270.18	5808.80
87	7569	658503	9.3274	4.4310	1.93952	11.4943	273.32	5944.68
88	7744	681472	9.3808	4.4480	1.94448	11.3636	276.46	6082.12
89	7921	704969	9.4340	4.4647	1.94939	11.2360	279.60	6221.14
90	8100	729000	9.4868	4.4814	1.95424	11.1111	282.74	6361.73
91	8281	753571	9.5394	4.4979	1.95904	10.9890	285.88	6503.88
92	8464	778688	9.5917	4.5144	1.96379	10.8696	289.03	6647.61
93	8649	804357	9.6437	4.5307	1.96848	10.7527	292.17	6792.91
94	8836	830584	9.6954	4.5468	1.97313	10.6383	295.31	6939.78
95	9025	857375	9.7468	4.5629	1.97772	10.5263	298.45	7088.22
96	9216	884736	9.7980	4.5789	1.98227	10.4167	301.59	7238.23
97	9409	912673	9.8489	4.5947	1.98677	10.3093	304.73	7389.81
98	9604	941192	9.8995	4.6104	1.99123	10.2041	307.88	7542.96
99	9801	970299	9.9499	4.6261	1.99564	10.1010	311.02	7697.69

100

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FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter	
							Circum.	Area
100	10000	1000000	10.0000	4.6416	2.00000	10.0000	314.16	7853.98
101	10201	1030301	10.0499	4.6570	2.00432	9.90099	317.30	8011.85
102	10404	1061208	10.0995	4.6723	2.00860	9.80392	320.44	8171.28
103	10609	1092727	10.1489	4.6875	2.01284	9.70874	323.58	8332.29
104	10816	1124864	10.1980	4.7027	2.01703	9.61538	326.73	8494.87
105	11025	1157625	10.2470	4.7177	2.02119	9.52381	329.87	8659.01
106	11236	1191016	10.2956	4.7326	2.02531	9.43396	333.01	8824.73
107	11449	1225043	10.3441	4.7475	2.02938	9.34579	336.15	8992.02
108	11664	1259712	10.3923	4.7622	2.03342	9.25926	339.29	9160.88
109	11881	1295029	10.4403	4.7769	2.03743	9.17431	342.43	9331.32
110	12100	1331000	10.4881	4.7914	2.04139	9.09091	345.58	9503.32
111	12321	1367631	10.5357	4.8059	2.04532	9.00901	348.72	9676.89
112	12544	1404928	10.5830	4.8203	2.04922	8.92857	351.86	9852.03
113	12769	1442897	10.6301	4.8346	2.05308	8.84956	355.00	10028.7
114	12996	1481544	10.6771	4.8488	2.05690	8.77193	358.14	10207.0
115	13225	1520875	10.7238	4.8629	2.06070	8.69565	361.28	10386.9
116	13456	1560896	10.7703	4.8770	2.06446	8.62069	364.42	10568.3
117	13689	1601613	10.8167	4.8910	2.06819	8.54701	367.57	10751.3
118	13924	1643032	10.8628	4.9049	2.07188	8.47458	370.71	10935.9
119	14161	1685159	10.9087	4.9187	2.07555	8.40336	373.85	11122.0
120	14400	1728000	10.9545	4.9324	2.07918	8.33333	376.99	11309.7
121	14641	1771561	11.0000	4.9461	2.08279	8.26446	380.13	11499.0
122	14884	1815848	11.0454	4.9597	2.08636	8.19672	383.27	11689.9
123	15129	1860867	11.0905	4.9732	2.08991	8.13008	386.42	11882.3
124	15376	1906624	11.1355	4.9866	2.09342	8.06452	389.56	12076.3
125	15625	1953125	11.1803	5.0000	2.09691	8.00000	392.70	12271.8
126	15876	2000376	11.2250	5.0133	2.10037	7.93651	395.84	12469.0
127	16129	2048383	11.2694	5.0265	2.10380	7.87402	398.98	12667.7
128	16384	2097152	11.3137	5.0397	2.10721	7.81250	402.12	12868.0
129	16641	2146689	11.3578	5.0528	2.11059	7.75194	405.27	13069.8
130	16900	2197000	11.4018	5.0658	2.11394	7.69231	408.41	13273.2
131	17161	2248091	11.4455	5.0788	2.11727	7.63359	411.55	13478.2
132	17424	2299968	11.4891	5.0916	2.12057	7.57576	414.69	13684.8
133	17689	2352637	11.5326	5.1045	2.12385	7.51880	417.83	13892.9
134	17956	2406104	11.5758	5.1172	2.12710	7.46269	420.97	14102.6
135	18225	2460375	11.6190	5.1299	2.13033	7.40741	424.12	14313.9
136	18496	2515456	11.6619	5.1426	2.13354	7.35294	427.26	14526.7
137	18769	2571353	11.7047	5.1551	2.13672	7.29927	430.40	14741.1
138	19044	2628072	11.7473	5.1676	2.13988	7.24638	433.54	14957.1
139	19321	2685619	11.7898	5.1801	2.14301	7.19424	436.68	15174.7
140	19600	2744000	11.8322	5.1925	2.14613	7.14286	439.82	15393.8
141	19881	2803221	11.8743	5.2048	2.14922	7.09220	442.96	15614.5
142	20164	2863288	11.9164	5.2171	2.15229	7.04225	446.11	15836.8
143	20449	2924207	11.9583	5.2293	2.15534	6.99301	449.25	16060.6
144	20736	2985984	12.0000	5.2415	2.15836	6.94444	452.39	16286.0
145	21025	3048625	12.0416	5.2536	2.16137	6.89655	455.53	16513.0
146	21316	3112136	12.0830	5.2656	2.16435	6.84932	458.67	16741.5
147	21609	3176523	12.1244	5.2776	2.16732	6.80272	461.81	16971.7
148	21904	3241792	12.1655	5.2896	2.17026	6.75676	464.96	17203.4
149	22201	3307949	12.2066	5.3015	2.17319	6.71141	468.10	17436.6

FUNCTIONS OF NUMBERS

150

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No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter	
							Circum.	Area
150	22500	3375000	12.2474	5.3133	2.17609	6.66667	471.24	17671.5
151	22801	3442951	12.2882	5.3251	2.17898	6.62252	474.38	17907.9
152	23104	3511808	12.3288	5.3368	2.18184	6.57895	477.52	18145.8
153	23409	3581577	12.3693	5.3485	2.18469	6.53595	480.66	18385.4
154	23716	3652264	12.4097	5.3601	2.18752	6.49351	483.81	18626.5
155	24025	3723875	12.4499	5.3717	2.19033	6.45161	486.95	18869.2
156	24336	3796416	12.4900	5.3832	2.19312	6.41026	490.09	19113.4
157	24649	3869893	12.5300	5.3947	2.19590	6.36943	493.23	19359.3
158	24964	3944312	12.5698	5.4061	2.19866	6.32911	496.37	19606.7
159	25281	4019679	12.6095	5.4175	2.20140	6.28931	499.51	19855.7
160	25600	4096000	12.6491	5.4288	2.20412	6.25000	502.65	20106.2
161	25921	4173281	12.6886	5.4401	2.20683	6.21118	505.80	20358.3
162	26244	4251528	12.7279	5.4514	2.20952	6.17284	508.94	20612.0
163	26569	4330747	12.7671	5.4626	2.21219	6.13497	512.08	20867.2
164	26896	4410944	12.8062	5.4737	2.2148	6.09756	515.22	21124.1
165	27225	4492125	12.8452	5.4848	2.21748	6.06061	518.36	21382.5
166	27556	4574296	12.8841	5.4959	2.22011	6.02410	521.50	21642.4
167	27889	4657463	12.9228	5.5069	2.22272	5.98802	524.65	21904.0
168	28224	4741632	12.9615	5.5178	2.22531	5.95238	527.79	22167.1
169	28561	4826809	13.0000	5.5288	2.22789	5.91716	530.93	22431.8
170	28900	4913000	13.0384	5.5397	2.23045	5.88235	534.07	22698.0
171	29241	5000211	13.0767	5.5505	2.23300	5.84795	537.21	22965.8
172	29584	5088448	13.1149	5.5613	2.23553	5.81395	540.35	23235.2
173	29929	5177717	13.1529	5.5721	2.23805	5.78035	543.50	23506.2
174	30276	5268024	13.1909	5.5828	2.24055	5.74713	546.64	23778.7
175	30625	5359375	13.2288	5.5934	2.24304	5.71429	549.78	24052.8
176	30976	5451776	13.2665	5.6041	2.24551	5.68182	552.92	24328.5
177	31329	5545233	13.3041	5.6147	2.24797	5.64972	556.06	24605.7
178	31684	5639752	13.3417	5.6252	2.25042	5.61798	559.20	24884.6
179	32041	5735339	13.3791	5.6357	2.25285	5.58659	562.35	25164.9
180	32400	5832000	13.4164	5.6462	2.25527	5.55556	565.49	25446.9
181	32761	5929741	13.4536	5.6567	2.25768	5.52486	568.63	25730.4
182	33124	6028568	13.4907	5.6671	2.26007	5.49451	571.77	26015.5
183	33489	6128487	13.5277	5.6774	2.26245	5.46448	574.91	26302.2
184	33856	6229504	13.5647	5.6877	2.26482	5.43478	578.05	26590.4
185	34225	6331625	13.6015	5.6980	2.26717	5.40541	581.19	26880.3
186	34596	6434856	13.6382	5.7083	2.26951	5.37634	584.34	27171.6
187	34969	6539203	13.6748	5.7185	2.27184	5.34759	587.48	27464.6
188	35344	6644672	13.7113	5.7287	2.27416	5.31915	590.62	27759.1
189	35721	6751269	13.7477	5.7388	2.27646	5.29101	593.76	28055.2
190	36100	6859000	13.7840	5.7489	2.27875	5.26316	596.90	28352.9
191	36481	6967871	13.8203	5.7590	2.28103	5.23560	600.04	28652.1
192	36864	7077888	13.8564	5.7690	2.28330	5.20833	603.19	28952.9
193	37249	7189057	13.8924	5.7790	2.28556	5.18135	606.33	29255.3
194	37636	7301384	13.9284	5.7890	2.28780	5.15464	609.47	29559.2
195	38025	7414875	13.9642	5.7989	2.29003	5.12821	612.61	29864.8
196	38416	7529536	14.0000	5.8088	2.29226	5.10204	615.75	30171.9
197	38809	7645373	14.0357	5.8186	2.29447	5.07614	618.89	30480.5
198	39204	7762392	14.0712	5.8285	2.29667	5.05051	622.04	30790.7
199	39601	7880599	14.1067	5.8383	2.29885	5.02513	625.18	31102.6

200

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FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter	
							Circum.	Area
200	40000	8000000	14.1421	5.8480	2.30103	5.00000	628.32	31415.9
201	40401	8120601	14.1774	5.8578	2.30320	4.97512	631.46	31730.9
202	40804	8242408	14.2127	5.8675	2.30535	4.95050	634.60	32047.4
203	41209	8365427	14.2478	5.8771	2.30750	4.92611	637.74	32365.5
204	41616	8489664	14.2829	5.8868	2.30963	4.90196	640.88	32685.1
205	42025	8615125	14.3178	5.8964	2.31175	4.87805	644.03	33006.4
206	42436	8741816	14.3527	5.9059	2.31387	4.85437	647.17	33329.2
207	42849	8869743	14.3875	5.9155	2.31597	4.83092	650.31	33653.5
208	43264	8998912	14.4222	5.9250	2.31806	4.80769	653.45	33979.5
209	43681	9129329	14.4568	5.9345	2.32015	4.78469	656.59	34307.0
210	44100	9261000	14.4914	5.9439	2.32222	4.76190	659.73	34636.1
211	44521	9393931	14.5258	5.9533	2.32428	4.73934	662.88	34966.7
212	44944	9528128	14.5602	5.9627	2.32634	4.71698	666.02	35298.9
213	45369	9663597	14.5945	5.9721	2.32838	4.69484	669.16	35632.7
214	45796	9800344	14.6287	5.9814	2.33041	4.67290	672.30	35968.1
215	46225	9938375	14.6629	5.9907	2.33244	4.65116	675.44	36305.0
216	46656	10077696	14.6969	6.0000	2.33445	4.62963	678.58	36643.5
217	47089	10218313	14.7309	6.0092	2.33646	4.60829	681.73	36983.6
218	47524	10360232	14.7648	6.0185	2.33846	4.58716	684.87	37325.3
219	47961	10503459	14.7986	6.0277	2.34044	4.56621	688.01	37668.5
220	48400	10648000	14.8324	6.0368	2.34242	4.54545	691.15	38013.3
221	48841	10793861	14.8661	6.0459	2.34439	4.52489	694.29	38359.6
222	49284	10941048	14.8997	6.0550	2.34635	4.50450	697.43	38707.6
223	49729	11089567	14.9332	6.0641	2.34830	4.48430	700.58	39057.1
224	50176	11239424	14.9666	6.0732	2.35025	4.46429	703.72	39408.1
225	50625	11390625	15.0000	6.0822	2.35218	4.44444	706.86	39760.8
226	51076	11543176	15.0333	6.0912	2.35411	4.42478	710.00	40115.0
227	51529	11697083	15.0665	6.1002	2.35603	4.40529	713.14	40470.8
228	51984	11852352	15.0997	6.1091	2.35793	4.38596	716.28	40828.1
229	52441	12008989	15.1327	6.1180	2.35984	4.36681	719.42	41187.1
230	52900	12167000	15.1658	6.1269	2.36173	4.34783	722.57	41547.6
231	53361	12326391	15.1987	6.1358	2.36361	4.32900	725.71	41909.6
232	53824	12487168	15.2315	6.1446	2.36549	4.31034	728.85	42273.3
233	54289	12649337	15.2643	6.1534	2.36736	4.29185	731.99	42638.5
234	54756	12812904	15.2971	6.1622	2.36922	4.27350	735.13	43005.3
235	55225	12977875	15.3297	6.1710	2.37107	4.25532	738.27	43373.6
236	55696	13144256	15.3623	6.1797	2.37291	4.23729	741.42	43743.5
237	56169	13312053	15.3948	6.1885	2.37475	4.21941	744.56	44115.0
238	56644	13481272	15.4272	6.1972	2.37658	4.20168	747.70	44488.1
239	57121	13651919	15.4596	6.2058	2.37840	4.18410	750.84	44862.7
240	57600	13824000	15.4919	6.2145	2.38021	4.16667	753.98	45238.9
241	58081	13997521	15.5242	6.2231	2.38202	4.14938	757.12	45616.7
242	58564	14172488	15.5563	6.2317	2.38382	4.13223	760.27	45996.1
243	59049	14348907	15.5885	6.2403	2.38561	4.11523	763.41	46377.0
244	59536	14526784	15.6205	6.2488	2.38739	4.09836	766.55	46759.5
245	60025	14706125	15.6525	6.2573	2.38917	4.08163	769.69	47143.5
246	60516	14886936	15.6844	6.2658	2.39094	4.06504	772.83	47529.2
247	61009	15069223	15.7162	6.2743	2.39270	4.04858	775.97	47916.4
248	61504	15252992	15.7480	6.2828	2.39445	4.03226	779.12	48305.1
249	62001	15438249	15.7797	6.2912	2.39620	4.01606	782.26	48695.5

FUNCTIONS OF NUMBERS

250

299

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter	
							Circum.	Area
250	62500	15625000	15.8114	6.2996	2.39794	4.00000	785.40	49087.4
251	63001	15813251	15.8430	6.3080	2.39967	3.98406	788.54	49480.9
252	63504	16003008	15.8745	6.3164	2.40140	3.96825	791.68	49875.9
253	64009	16194277	15.9060	6.3247	2.40312	3.95257	794.82	50272.6
254	64516	16387064	15.9374	6.3330	2.40483	3.93701	797.96	50670.7
255	65025	16581375	15.9687	6.3413	2.40654	3.92157	801.11	51070.5
256	65536	16777216	16.0000	6.3496	2.40824	3.90625	804.25	51471.9
257	66049	16974593	16.0312	6.3579	2.40993	3.89105	807.39	51874.8
258	66564	17173512	16.0624	6.3661	2.41162	3.87597	810.53	52279.2
259	67081	17373979	16.0935	6.3743	2.41330	3.86100	813.67	52685.3
260	67600	17576000	16.1245	6.3825	2.41497	3.84615	816.81	53092.9
261	68121	17779581	16.1555	6.3907	2.41664	3.83142	819.96	53502.1
262	68644	17984728	16.1864	6.3988	2.41830	3.81679	823.10	53912.9
263	69169	18191447	16.2173	6.4070	2.41996	3.80228	826.24	54325.2
264	69696	18399744	16.2481	6.4151	2.42160	3.78788	829.38	54739.1
265	70225	18609625	16.2788	6.4232	2.42325	3.77358	832.52	55154.6
266	70756	18821096	16.3095	6.4312	2.42488	3.75940	835.66	55571.6
267	71289	19034163	16.3401	6.4393	2.42651	3.74532	838.81	55990.2
268	71824	19248832	16.3707	6.4473	2.42813	3.73134	841.95	56410.4
269	72361	19465109	16.4012	6.4553	2.42975	3.71747	845.09	56832.2
270	72900	19683000	16.4317	6.4633	2.43136	3.70370	848.23	57255.5
271	73441	19902511	16.4621	6.4713	2.43297	3.69004	851.37	57680.4
272	73984	20123648	16.4924	6.4792	2.43457	3.67647	854.51	58106.9
273	74529	20346417	16.5227	6.4872	2.43616	3.66300	857.65	58534.9
274	75076	20570824	16.5529	6.4951	2.43775	3.64964	860.80	58964.6
275	75625	20796875	16.5831	6.5030	2.43933	3.63636	863.94	59395.7
276	76176	21024576	16.6132	6.5108	2.44091	3.62319	867.08	59828.5
277	76729	21253933	16.6433	6.5187	2.44248	3.61011	870.22	60262.8
278	77284	21484952	16.6733	6.5265	2.44404	3.59712	873.36	60698.7
279	77841	21717639	16.7033	6.5343	2.44560	3.58423	876.50	61136.2
280	78400	21952000	16.7332	6.5421	2.44716	3.57143	879.65	61575.2
281	78961	22188041	16.7631	6.5499	2.44871	3.55872	882.79	62015.8
282	79524	22425768	16.7929	6.5577	2.45025	3.54610	885.93	62458.0
283	80089	22665187	16.8226	6.5654	2.45179	3.53357	889.07	62901.8
284	80656	22906304	16.8523	6.5731	2.45332	3.52113	892.21	63347.1
285	81225	23149125	16.8819	6.5808	2.45484	3.50877	895.35	63794.0
286	81796	23393656	16.9115	6.5885	2.45637	3.49650	898.50	64242.4
287	82369	23639903	16.9411	6.5962	2.45788	3.48432	901.64	64692.5
288	82944	23887872	16.9706	6.6039	2.45939	3.47222	904.78	65144.1
289	83521	24137569	17.0000	6.6115	2.46090	3.46021	907.92	65597.2
290	84100	24389000	17.0294	6.6191	2.46240	3.44828	911.06	66052.0
291	84681	24642171	17.0587	6.6267	2.46389	3.43643	914.20	66508.3
292	85264	24897088	17.0880	6.6343	2.46538	3.42466	917.35	66966.2
293	85849	25153757	17.1172	6.6419	2.46687	3.41297	920.49	67425.6
294	86436	25412184	17.1464	6.6494	2.46835	3.40136	923.63	67886.7
295	87025	25672375	17.1756	6.6569	2.46982	3.38983	926.77	68349.3
296	87616	25934336	17.2047	6.6644	2.47129	3.37838	929.91	68813.4
297	88209	26198073	17.2337	6.6719	2.47276	3.36700	933.05	69279.2
298	88804	26463592	17.2627	6.6794	2.47422	3.35570	936.19	69746.5
299	89401	26730899	17.2916	6.6869	2.47567	3.34448	939.34	70215.4

300

349

FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter	
							Circum.	Area
300	90000	27000000	17.3205	6.6943	2.47712	3.33333	942.48	70685.8
301	90601	27270901	17.3494	6.7018	2.47857	3.32226	945.62	71157.9
302	91204	27543608	17.3781	6.7092	2.48001	3.31126	948.76	71631.5
303	91809	27818127	17.4069	6.7166	2.48144	3.30033	951.90	72106.6
304	92416	28094464	17.4356	6.7240	2.48287	3.28947	955.04	72583.4
305	93025	28372625	17.4642	6.7313	2.48430	3.27869	958.19	73061.7
306	93636	28652616	17.4929	6.7387	2.48572	3.26797	961.33	73541.5
307	94249	28934443	17.5214	6.7460	2.48714	3.25733	964.47	74023.0
308	94864	29218112	17.5499	6.7533	2.48855	3.24675	967.61	74506.0
309	95481	29503629	17.5784	6.7606	2.48996	3.23625	970.75	74990.6
310	96100	29791000	17.6068	6.7679	2.49136	3.22581	973.89	75476.8
311	96721	30080231	17.6352	6.7752	2.49276	3.21543	977.04	75964.5
312	97344	30371328	17.6635	6.7824	2.49415	3.20513	980.18	76453.8
313	97969	30664297	17.6918	6.7897	2.49554	3.19489	983.32	76944.7
314	98596	30959144	17.7200	6.7969	2.49693	3.18471	986.46	77437.1
315	99225	31255875	17.7482	6.8041	2.49831	3.17460	989.60	77931.1
316	99856	31554496	17.7764	6.8113	2.49969	3.16456	992.74	78426.7
317	100489	31855013	17.8045	6.8185	2.50106	3.15457	995.88	78923.9
318	101124	32157432	17.8326	6.8256	2.50243	3.14465	999.03	79422.6
319	101761	32461759	17.8606	6.8328	2.50379	3.13480	1002.2	79922.9
320	102400	32768000	17.8885	6.8399	2.50515	3.12500	1005.3	80424.8
321	103041	33076161	17.9165	6.8470	2.50651	3.11526	1008.5	80928.2
322	103684	33386248	17.9444	6.8541	2.50786	3.10559	1011.6	81433.2
323	104329	33698267	17.9722	6.8612	2.50920	3.09598	1014.7	81939.8
324	104976	34012224	18.0000	6.8683	2.51055	3.08642	1017.9	82448.0
325	105625	34328125	18.0278	6.8753	2.51188	3.07692	1021.0	82957.7
326	106276	34645976	18.0555	6.8824	2.51322	3.06749	1024.2	83469.0
327	106929	34965783	18.0831	6.8894	2.51455	3.05810	1027.3	83981.8
328	107584	35287552	18.1108	6.8964	2.51587	3.04878	1030.4	84496.3
329	108241	35611289	18.1384	6.9034	2.51720	3.03951	1033.6	85012.3
330	108900	35937000	18.1659	6.9104	2.51851	3.03030	1036.7	85529.9
331	109561	36264691	18.1934	6.9174	2.51983	3.02115	1039.9	86049.0
332	110224	36594368	18.2209	6.9244	2.52114	3.01205	1043.0	86569.7
333	110889	36926037	18.2483	6.9313	2.52244	3.00300	1046.2	87092.0
334	111556	37259704	18.2757	6.9382	2.52375	2.99401	1049.3	87615.9
335	112225	37595375	18.3030	6.9451	2.52504	2.98507	1052.4	88141.3
336	112896	37933056	18.3303	6.9521	2.52634	2.97619	1055.6	88668.3
337	113569	38272753	18.3576	6.9589	2.52763	2.96736	1058.7	89196.9
338	114244	38614472	18.3848	6.9658	2.52892	2.95858	1061.9	89727.0
339	114921	38958219	18.4120	6.9727	2.53020	2.94985	1065.0	90258.7
340	115600	39304000	18.4391	6.9795	2.53148	2.94118	1068.1	90792.0
341	116281	39651821	18.4662	6.9864	2.53275	2.93255	1071.3	91326.9
342	116964	40001688	18.4932	6.9932	2.53403	2.92398	1074.4	91863.3
343	117649	40353607	18.5203	7.0000	2.53529	2.91545	1077.6	92401.3
344	118336	40707584	18.5472	7.0068	2.53656	2.90698	1080.7	92940.9
345	119025	41063625	18.5742	7.0136	2.53782	2.89855	1083.8	93482.0
346	119716	41421736	18.6011	7.0203	2.53908	2.89017	1087.0	94024.7
347	120409	41781923	18.6279	7.0271	2.54033	2.88184	1090.1	94569.0
348	121104	42144192	18.6548	7.0338	2.54158	2.87356	1093.3	95114.9
349	121801	42508549	18.6815	7.0406	2.54283	2.86533	1096.4	95662.3

FUNCTIONS OF NUMBERS

350

399

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter	
							Circum.	Area
350	122500	42875000	18.7083	7.0473	2.54407	2.85714	1099.6	96211.3
351	123201	43243551	18.7350	7.0540	2.54531	2.84900	1102.7	96761.8
352	123904	43614208	18.7617	7.0607	2.54654	2.84091	1105.8	97314.0
353	124609	43986977	18.7883	7.0674	2.54777	2.83286	1109.0	97867.7
354	125316	44361864	18.8149	7.0740	2.54900	2.82486	1112.1	98423.0
355	126025	44738875	18.8414	7.0807	2.55023	2.81690	1115.3	98979.8
356	126736	45118016	18.8680	7.0873	2.55145	2.80899	1118.4	99538.2
357	127449	45499293	18.8944	7.0940	2.55267	2.80112	1121.5	100098
358	128164	45882712	18.9209	7.1006	2.55388	2.79330	1124.7	100660
359	128881	46268279	18.9473	7.1072	2.55509	2.78552	1127.8	101223
360	129600	46656000	18.9737	7.1138	2.55630	2.77778	1131.0	101788
361	130321	47045881	19.0000	7.1204	2.55751	2.77008	1134.1	102354
362	131044	47437928	19.0263	7.1269	2.55871	2.76243	1137.3	102922
363	131769	47832147	19.0526	7.1335	2.55991	2.75482	1140.4	103491
364	132496	48228544	19.0788	7.1400	2.56110	2.74725	1143.5	104062
365	133225	48627125	19.1050	7.1466	2.56229	2.73973	1146.7	104635
366	133956	49027896	19.1311	7.1531	2.56348	2.73224	1149.8	105209
367	134689	49430863	19.1572	7.1596	2.56467	2.72480	1153.0	105785
368	135424	49836032	19.1833	7.1661	2.56585	2.71739	1156.1	106362
369	136161	50243409	19.2094	7.1726	2.56703	2.71003	1159.2	106941
370	136900	50653000	19.2354	7.1791	2.56820	2.70270	1162.4	107521
371	137641	51064811	19.2614	7.1855	2.56937	2.69542	1165.5	108103
372	138384	51478848	19.2873	7.1920	2.57054	2.68817	1168.7	108687
373	139129	51895117	19.3132	7.1984	2.57171	2.68097	1171.8	109272
374	139876	52313624	19.3391	7.2048	2.57287	2.67380	1175.0	109858
375	140625	52734375	19.3649	7.2112	2.57403	2.66667	1178.1	110447
376	141376	53157376	19.3907	7.2177	2.57519	2.65957	1181.2	111036
377	142129	53582633	19.4165	7.2240	2.57634	2.65252	1184.4	111628
378	142884	54010152	19.4422	7.2304	2.57749	2.64550	1187.5	112221
379	143641	54439939	19.4679	7.2368	2.57864	2.63852	1190.7	112815
380	144400	54872000	19.4936	7.2432	2.57978	2.63158	1193.8	113411
381	145161	55306341	19.5192	7.2495	2.58093	2.62467	1196.9	114009
382	145924	55742968	19.5448	7.2558	2.58206	2.61780	1200.1	114608
383	146689	56181887	19.5704	7.2622	2.58320	2.61097	1203.2	115209
384	147456	56623104	19.5959	7.2685	2.58433	2.60417	1206.4	115812
385	148225	57066625	19.6214	7.2748	2.58546	2.59740	1209.5	116416
386	148996	57512456	19.6469	7.2811	2.58659	2.59067	1212.7	117021
387	149769	57960603	19.6723	7.2874	2.58771	2.58398	1215.8	117628
388	150544	58411072	19.6977	7.2936	2.58883	2.57732	1218.9	118237
389	151321	58863869	19.7231	7.2999	2.58995	2.57069	1222.1	118847
390	152100	59319000	19.7484	7.3061	2.59106	2.56410	1225.2	119459
391	152881	59776471	19.7737	7.3124	2.59218	2.55754	1228.4	120072
392	153664	60236288	19.7990	7.3186	2.59329	2.55102	1231.5	120687
393	154449	60698457	19.8242	7.3248	2.59439	2.54453	1234.6	121304
394	155236	61162984	19.8494	7.3310	2.59550	2.53807	1237.8	121922
395	156025	61629875	19.8746	7.3372	2.59660	2.53165	1240.9	122542
396	156816	62099136	19.8997	7.3434	2.59770	2.52525	1244.1	123163
397	157609	62570773	19.9249	7.3496	2.59879	2.51889	1247.2	123786
398	158404	63044792	19.9499	7.3558	2.59988	2.51256	1250.4	124410
399	159201	63521199	19.9750	7.3619	2.60097	2.50627	1253.5	125036

400

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FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter	
							Circum.	Area
400	160000	64000000	20.0000	7.3681	2.60206	2.50000	1256.6	125664
401	160801	64481201	20.0250	7.3742	2.60314	2.49377	1259.8	126293
402	161604	64964808	20.0499	7.3803	2.60423	2.48756	1262.9	126923
403	162409	65450827	20.0749	7.3864	2.60531	2.48139	1266.1	127556
404	163216	65939264	20.0998	7.3925	2.60638	2.47525	1269.2	128190
405	164025	66430125	20.1246	7.3986	2.60746	2.46914	1272.3	128825
406	164836	66923416	20.1494	7.4047	2.60853	2.46305	1275.5	129462
407	165649	67419143	20.1742	7.4108	2.60959	2.45700	1278.6	130100
408	166464	67917312	20.1990	7.4169	2.61066	2.45098	1281.8	130741
409	167281	68417929	20.2237	7.4229	2.61172	2.44499	1284.9	131382
410	168100	68921000	20.2485	7.4290	2.61278	2.43902	1288.1	132025
411	168921	69426531	20.2731	7.4350	2.61384	2.43309	1291.2	132670
412	169744	69934528	20.2978	7.4410	2.61490	2.42718	1294.3	133317
413	170569	70444997	20.3224	7.4470	2.61595	2.42131	1297.5	133965
414	171396	70957944	20.3470	7.4530	2.61700	2.41546	1300.6	134614
415	172225	71473375	20.3715	7.4590	2.61805	2.40964	1303.8	135265
416	173056	71991296	20.3961	7.4650	2.61909	2.40385	1306.9	135918
417	173889	72511713	20.4206	7.4710	2.62014	2.39808	1310.0	136572
418	174724	73034632	20.4450	7.4770	2.62118	2.39234	1313.2	137228
419	175561	73560059	20.4695	7.4829	2.62221	2.38663	1316.3	137885
420	176400	74088000	20.4939	7.4889	2.62325	2.38095	1319.5	138544
421	177241	74618461	20.5183	7.4948	2.62428	2.37530	1322.6	139205
422	178084	75151448	20.5426	7.5007	2.62531	2.36967	1325.8	139867
423	178929	75686967	20.5670	7.5067	2.62634	2.36407	1328.9	140531
424	179776	76225024	20.5913	7.5126	2.62737	2.35849	1332.0	141196
425	180625	76765625	20.6155	7.5185	2.62839	2.35294	1335.2	141863
426	181476	77308776	20.6398	7.5244	2.62941	2.34742	1338.3	142531
427	182329	77854483	20.6640	7.5302	2.63043	2.34192	1341.5	143201
428	183184	78402752	20.6882	7.5361	2.63144	2.33645	1344.6	143872
429	184041	78953589	20.7123	7.5420	2.63246	2.33100	1347.7	144545
430	184900	79507000	20.7364	7.5478	2.63347	2.32558	1350.9	145220
431	185761	80062991	20.7605	7.5537	2.63448	2.32019	1354.0	145896
432	186624	80621568	20.7846	7.5595	2.63548	2.31481	1357.2	146574
433	187489	81182737	20.8087	7.5654	2.63649	2.30947	1360.3	147254
434	188356	81746504	20.8327	7.5712	2.63749	2.30415	1363.5	147934
435	189225	82312875	20.8567	7.5770	2.63849	2.29885	1366.6	148617
436	190096	82881856	20.8806	7.5828	2.63949	2.29358	1369.7	149301
437	190969	83453453	20.9045	7.5886	2.64048	2.28833	1372.9	149987
438	191844	84027672	20.9284	7.5944	2.64147	2.28311	1376.0	150674
439	192721	84604519	20.9523	7.6001	2.64246	2.27790	1379.2	151363
440	193600	85184000	20.9762	7.6059	2.64345	2.27273	1382.3	152053
441	194481	85766121	21.0000	7.6117	2.64444	2.26757	1385.4	152745
442	195364	86350888	21.0238	7.6174	2.64542	2.26244	1388.6	153439
443	196249	86938307	21.0476	7.6232	2.64640	2.25734	1391.7	154134
444	197136	87528384	21.0713	7.6289	2.64738	2.25225	1394.9	154830
445	198025	88121125	21.0950	7.6346	2.64836	2.24719	1398.0	155528
446	198916	88716536	21.1187	7.6403	2.64933	2.24215	1401.2	156228
447	199809	89314623	21.1424	7.6460	2.65031	2.23714	1404.3	156930
448	200704	89915392	21.1660	7.6517	2.65128	2.23214	1407.4	157633
449	201601	90518849	21.1896	7.6574	2.65225	2.22717	1410.6	158337

FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter	
							Circum.	Area
450	202500	91125000	21.2132	7.6631	2.65321	2.22222	1413.7	159043
451	203401	91733851	21.2368	7.6688	2.65418	2.21729	1416.9	159751
452	204304	92345408	21.2603	7.6744	2.65514	2.21239	1420.0	160460
453	205209	92959677	21.2838	7.6801	2.65610	2.20751	1423.1	161171
454	206116	93576664	21.3073	7.6857	2.65706	2.20264	1426.3	161883
455	207025	94196375	21.3307	7.6914	2.65801	2.19780	1429.4	162597
456	207936	94818816	21.3542	7.6970	2.65896	2.19298	1432.6	163313
457	208849	95443993	21.3776	7.7026	2.65992	2.18818	1435.7	164030
458	209764	96071912	21.4009	7.7082	2.66087	2.18341	1438.8	164748
459	210681	96702579	21.4243	7.7138	2.66181	2.17865	1442.0	165468
460	211600	97336000	21.4476	7.7194	2.66276	2.17391	1445.1	166190
461	212521	97972181	21.4709	7.7250	2.66370	2.16920	1448.3	166914
462	213444	98611128	21.4942	7.7306	2.66464	2.16450	1451.4	167639
463	214369	99252847	21.5174	7.7362	2.66558	2.15983	1454.6	168365
464	215296	99897344	21.5407	7.7418	2.66652	2.15517	1457.7	169093
465	216225	100544625	21.5639	7.7473	2.66745	2.15054	1460.8	169823
466	217156	101194696	21.5870	7.7529	2.66839	2.14592	1464.0	170554
467	218089	101847563	21.6102	7.7584	2.66932	2.14133	1467.1	171287
468	219024	102503232	21.6333	7.7639	2.67025	2.13675	1470.3	172021
469	219961	103161709	21.6564	7.7695	2.67117	2.13220	1473.4	172757
470	220900	103823000	21.6795	7.7750	2.67210	2.12766	1476.5	173494
471	221841	104487111	21.7025	7.7805	2.67302	2.12314	1479.7	174234
472	222784	105154048	21.7256	7.7860	2.67394	2.11864	1482.8	174974
473	223729	105823817	21.7486	7.7915	2.67486	2.11416	1486.0	175716
474	224676	106496424	21.7715	7.7970	2.67578	2.10970	1489.1	176460
475	225625	107171875	21.7945	7.8025	2.67669	2.10526	1492.3	177205
476	226576	107850176	21.8174	7.8079	2.67761	2.10084	1495.4	177952
477	227529	108531333	21.8403	7.8134	2.67852	2.09644	1498.5	178701
478	228484	109215352	21.8632	7.8188	2.67943	2.09205	1501.7	179451
479	229441	109902239	21.8861	7.8243	2.68034	2.08768	1504.8	180203
480	230400	110592000	21.9089	7.8297	2.68124	2.08333	1508.0	180956
481	231361	111284641	21.9317	7.8352	2.68215	2.07900	1511.1	181711
482	232324	111980168	21.9545	7.8406	2.68305	2.07469	1514.2	182467
483	233289	112678587	21.9773	7.8460	2.68395	2.07039	1517.4	183225
484	234256	113379904	22.0000	7.8514	2.68485	2.06612	1520.5	183984
485	235225	114084125	22.0227	7.8568	2.68574	2.06186	1523.7	184745
486	236196	114791256	22.0454	7.8622	2.68664	2.05761	1526.8	185508
487	237169	115501303	22.0681	7.8676	2.68753	2.05339	1530.0	186272
488	238144	116214272	22.0907	7.8730	2.68842	2.04918	1533.1	187038
489	239121	116930169	22.1133	7.8784	2.68931	2.04499	1536.2	187805
490	240100	117649000	22.1359	7.8837	2.69020	2.04082	1539.4	188574
491	241081	118370771	22.1585	7.8891	2.69108	2.03666	1542.5	189345
492	242064	119095488	22.1811	7.8944	2.69197	2.03252	1545.7	190117
493	243049	119823157	22.2036	7.8998	2.69285	2.02840	1548.8	190890
494	244036	120553784	22.2261	7.9051	2.69373	2.02429	1551.9	191665
495	245025	121287375	22.2486	7.9105	2.69461	2.02020	1555.1	192442
496	246016	122023936	22.2711	7.9158	2.69548	2.01613	1558.2	193221
497	247009	122763473	22.2935	7.9211	2.69636	2.01207	1561.4	194000
498	248004	123505992	22.3159	7.9264	2.69723	2.00803	1564.5	194782
499	249001	124251499	22.3383	7.9317	2.69810	2.00401	1567.7	195565

500

549

FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter	
							Circum.	Area
500	250000	125000000	22.3607	7.9370	2.69897	2.00000	1570.8	196350
501	251001	125751501	22.3830	7.9423	2.69984	1.99601	1573.9	197136
502	252004	126506008	22.4054	7.9476	2.70070	1.99203	1577.1	197923
503	253009	127263527	22.4277	7.9528	2.70157	1.98807	1580.2	198713
504	254016	128024064	22.4499	7.9581	2.70243	1.98413	1583.4	199504
505	255025	128787625	22.4722	7.9634	2.70329	1.98020	1586.5	200296
506	256036	129554216	22.4944	7.9686	2.70415	1.97628	1589.6	201090
507	257049	130323843	22.5167	7.9739	2.70501	1.97239	1592.8	201886
508	258064	131096512	22.5389	7.9791	2.70586	1.96850	1595.9	202683
509	259081	131872229	22.5610	7.9843	2.70672	1.96464	1599.1	203482
510	260100	132651000	22.5832	7.9896	2.70757	1.96078	1602.2	204282
511	261121	133432831	22.6053	7.9948	2.70842	1.95695	1605.4	205084
512	262144	134217728	22.6274	8.0000	2.70927	1.95312	1608.5	205887
513	263169	135005697	22.6495	8.0052	2.71012	1.94932	1611.6	206692
514	264196	135796744	22.6716	8.0104	2.71096	1.94553	1614.8	207499
515	265225	136590875	22.6936	8.0156	2.71181	1.94175	1617.9	208307
516	266256	137388096	22.7156	8.0208	2.71265	1.93798	1621.1	209117
517	267289	138188413	22.7376	8.0260	2.71349	1.93424	1624.2	209928
518	268324	138991832	22.7596	8.0311	2.71433	1.93050	1627.3	210741
519	269361	139798359	22.7816	8.0363	2.71517	1.92678	1630.5	211556
520	270400	140608000	22.8035	8.0415	2.71600	1.92308	1633.6	212372
521	271441	141420761	22.8254	8.0466	2.71684	1.91939	1636.8	213189
522	272484	142236648	22.8473	8.0517	2.71767	1.91571	1639.9	214008
523	273529	143055667	22.8692	8.0569	2.71850	1.91205	1643.1	214829
524	274576	143877824	22.8910	8.0620	2.71933	1.90840	1646.2	215651
525	275625	144703125	22.9129	8.0671	2.72016	1.90476	1649.3	216475
526	276676	145531576	22.9347	8.0723	2.72099	1.90114	1652.5	217301
527	277729	146363183	22.9565	8.0774	2.72181	1.89753	1655.6	218128
528	278784	147197952	22.9783	8.0825	2.72263	1.89394	1658.8	218956
529	279841	148035889	23.0000	8.0876	2.72346	1.89036	1661.9	219787
530	280900	148877000	23.0217	8.0927	2.72428	1.88679	1665.0	220618
531	281961	149721291	23.0434	8.0978	2.72509	1.88324	1668.2	221452
532	283024	150568768	23.0651	8.1028	2.72591	1.87970	1671.3	222287
533	284089	151419437	23.0868	8.1079	2.72673	1.87617	1674.5	223123
534	285156	152273304	23.1084	8.1130	2.72754	1.87266	1677.6	223961
535	286225	153130375	23.1301	8.1180	2.72835	1.86916	1680.8	224801
536	287296	153990656	23.1517	8.1231	2.72916	1.86567	1683.9	225642
537	288369	154854153	23.1733	8.1281	2.72997	1.86220	1687.0	226484
538	289444	155720872	23.1948	8.1332	2.73078	1.85874	1690.2	227329
539	290521	156590819	23.2164	8.1382	2.73159	1.85529	1693.3	228175
540	291600	157464000	23.2379	8.1433	2.73239	1.85185	1696.5	229022
541	292681	158340421	23.2594	8.1483	2.73320	1.84843	1699.6	229871
542	293764	159220088	23.2809	8.1533	2.73400	1.84502	1702.7	230722
543	294849	160103007	23.3024	8.1583	2.73480	1.84162	1705.9	231574
544	295936	160989184	23.3238	8.1633	2.73560	1.83824	1709.0	232428
545	297025	161878625	23.3452	8.1683	2.73640	1.83486	1712.2	233283
546	298116	162771336	23.3666	8.1733	2.73719	1.83150	1715.3	234140
547	299209	163667323	23.3880	8.1783	2.73799	1.82815	1718.5	234998
548	300304	164566592	23.4094	8.1833	2.73878	1.82482	1721.6	235858
549	301401	165469149	23.4307	8.1882	2.73957	1.82149	1724.7	236720

FUNCTIONS OF NUMBERS

550

599

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter	
							Circum.	Area
550	302500	166375000	23.4521	8.1932	2.74036	1.81818	1727.9	237583
551	303601	167284151	23.4734	8.1982	2.74115	1.81488	1731.0	238448
552	304704	168196608	23.4947	8.2031	2.74194	1.81159	1734.2	239314
553	305809	169112377	23.5160	8.2081	2.74273	1.80832	1737.3	240182
554	306916	170031464	23.5372	8.2130	2.74351	1.80505	1740.4	241051
555	308025	170953875	23.5584	8.2180	2.74429	1.80180	1743.6	241922
556	309136	171879616	23.5797	8.2229	2.74507	1.79856	1746.7	242795
557	310249	172808693	23.6008	8.2278	2.74586	1.79533	1749.9	243669
558	311364	173741112	23.6220	8.2327	2.74663	1.79211	1753.0	244545
559	312481	174676879	23.6432	8.2377	2.74741	1.78891	1756.2	245422
560	313600	175616000	23.6643	8.2426	2.74819	1.78571	1759.3	246301
561	314721	176558481	23.6854	8.2475	2.74896	1.78253	1762.4	247181
562	315844	177504328	23.7065	8.2524	2.74974	1.77936	1765.6	248063
563	316969	178453547	23.7276	8.2573	2.75051	1.77620	1768.7	248947
564	318096	179406144	23.7487	8.2621	2.75128	1.77305	1771.9	249832
565	319225	180362125	23.7697	8.2670	2.75205	1.76991	1775.0	250719
566	320356	181321496	23.7908	8.2719	2.75282	1.76678	1778.1	251607
567	321489	182284263	23.8118	8.2768	2.75358	1.76367	1781.3	252497
568	322624	183250432	23.8328	8.2816	2.75435	1.76056	1784.4	253388
569	323761	184220009	23.8537	8.2865	2.75511	1.75747	1787.6	254281
570	324900	185193000	23.8747	8.2913	2.75587	1.75439	1790.7	255176
571	326041	186169411	23.8956	8.2962	2.75664	1.75131	1793.8	256072
572	327184	187149248	23.9165	8.3010	2.75740	1.74825	1797.0	256970
573	328329	188132517	23.9374	8.3059	2.75815	1.74520	1800.1	257869
574	329476	189119224	23.9583	8.3107	2.75891	1.74216	1803.3	258770
575	330625	190109375	23.9792	8.3155	2.75967	1.73913	1806.4	259672
576	331776	191102976	24.0000	8.3203	2.76042	1.73611	1809.6	260576
577	332929	192100033	24.0208	8.3251	2.76118	1.73310	1812.7	261482
578	334084	193100552	24.0416	8.3300	2.76193	1.73010	1815.8	262389
579	335241	194104539	24.0624	8.3348	2.76268	1.72712	1819.0	263298
580	336400	195112000	24.0832	8.3396	2.76343	1.72414	1822.1	264208
581	337561	196122941	24.1039	8.3443	2.76418	1.72117	1825.3	265120
582	338724	197137368	24.1247	8.3491	2.76492	1.71821	1828.4	266033
583	339889	198155287	24.1454	8.3539	2.76567	1.71527	1831.6	266948
584	341056	199176704	24.1661	8.3587	2.76641	1.71233	1834.7	267865
585	342225	200201625	24.1868	8.3634	2.76716	1.70940	1837.8	268783
586	343396	201230056	24.2074	8.3682	2.76790	1.70648	1841.0	269703
587	344569	202262003	24.2281	8.3730	2.76864	1.70358	1844.1	270624
588	345744	203297472	24.2487	8.3777	2.76938	1.70068	1847.3	271547
589	346921	204336469	24.2693	8.3825	2.77012	1.69779	1850.4	272471
590	348100	205379000	24.2899	8.3872	2.77085	1.69492	1853.5	273397
591	349281	206425071	24.3105	8.3919	2.77159	1.69205	1856.7	274325
592	350464	207474688	24.3311	8.3967	2.77232	1.68919	1859.8	275254
593	351649	208527857	24.3516	8.4014	2.77305	1.68634	1863.0	276184
594	352836	209584584	24.3721	8.4061	2.77379	1.68350	1866.1	277117
595	354025	210644875	24.3926	8.4108	2.77452	1.68067	1869.2	278051
596	355216	211708736	24.4131	8.4155	2.77525	1.67785	1872.4	278986
597	356409	212776173	24.4336	8.4202	2.77597	1.67504	1875.5	279923
598	357604	213847192	24.4540	8.4249	2.77670	1.67224	1878.7	280862
599	358801	214921799	24.4745	8.4296	2.77743	1.66945	1881.8	281802

600

649

FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter	
							Circum.	Area
600	360000	216000000	24.4949	8.4343	2.77815	1.66667	1885.0	282743
601	361201	217081801	24.5153	8.4390	2.77887	1.66389	1888.1	283687
602	362404	218167208	24.5357	8.4437	2.77960	1.66113	1891.2	284631
603	363609	219256227	24.5561	8.4484	2.78032	1.65837	1894.4	285578
604	364816	220348864	24.5764	8.4530	2.78104	1.65563	1897.5	286526
605	366025	221445125	24.5967	8.4577	2.78176	1.65289	1900.7	287475
606	367236	222545016	24.6171	8.4623	2.78247	1.65017	1903.8	288426
607	368449	223648543	24.6374	8.4670	2.78319	1.64745	1906.9	289379
608	369664	224755712	24.6577	8.4716	2.78390	1.64474	1910.1	290333
609	370881	225866529	24.6779	8.4763	2.78462	1.64204	1913.2	291289
610	372100	226981000	24.6982	8.4809	2.78533	1.63934	1916.4	292247
611	373321	228099131	24.7184	8.4856	2.78604	1.63666	1919.5	293206
612	374544	229220928	24.7386	8.4902	2.78675	1.63399	1922.7	294166
613	375769	230346397	24.7588	8.4948	2.78746	1.63132	1925.8	295128
614	376996	231475544	24.7790	8.4994	2.78817	1.62866	1928.9	296092
615	378225	232608375	24.7992	8.5040	2.78888	1.62602	1932.1	297057
616	379456	233744896	24.8193	8.5086	2.78958	1.62338	1935.2	298024
617	380689	234885113	24.8395	8.5132	2.79029	1.62075	1938.4	298992
618	381924	236029032	24.8596	8.5178	2.79099	1.61812	1941.5	299962
619	383161	237176659	24.8797	8.5224	2.79169	1.61551	1944.6	300934
620	384400	238328000	24.8998	8.5270	2.79239	1.61290	1947.8	301907
621	385641	239483061	24.9199	8.5316	2.79309	1.61031	1950.9	302882
622	386884	240641848	24.9399	8.5362	2.79379	1.60772	1954.1	303858
623	388129	241804367	24.9600	8.5408	2.79449	1.60514	1957.2	304836
624	389376	242970624	24.9800	8.5453	2.79518	1.60256	1960.4	305815
625	390625	244140625	25.0000	8.5499	2.79588	1.60000	1963.5	306796
626	391876	245314376	25.0200	8.5544	2.79657	1.59744	1966.6	307779
627	393129	246491883	25.0400	8.5590	2.79727	1.59490	1969.8	308763
628	394384	247673152	25.0599	8.5635	2.79796	1.59236	1972.9	309748
629	395641	248858189	25.0799	8.5681	2.79865	1.58983	1976.1	310736
630	396900	250047000	25.0998	8.5726	2.79934	1.58730	1979.2	311725
631	398161	251239591	25.1197	8.5772	2.80003	1.58479	1982.3	312715
632	399424	252435968	25.1396	8.5817	2.80072	1.58228	1985.5	313707
633	400689	253636137	25.1595	8.5862	2.80140	1.57978	1988.6	314700
634	401956	254840104	25.1794	8.5907	2.80209	1.57729	1991.8	315696
635	403225	256047875	25.1992	8.5952	2.80277	1.57480	1994.9	316692
636	404496	257259456	25.2190	8.5997	2.80346	1.57233	1998.1	317690
637	405769	258474853	25.2389	8.6043	2.80414	1.56986	2001.2	318690
638	407044	259694072	25.2587	8.6088	2.80482	1.56740	2004.3	319692
639	408321	260917119	25.2784	8.6132	2.80550	1.56495	2007.5	320695
640	409600	262144000	25.2982	8.6177	2.80618	1.56250	2010.6	321699
641	410881	263374721	25.3180	8.6222	2.80686	1.56006	2013.8	322705
642	412164	264609288	25.3377	8.6267	2.80754	1.55763	2016.9	323713
643	413449	265847707	25.3574	8.6312	2.80821	1.55521	2020.0	324722
644	414736	267089984	25.3772	8.6357	2.80889	1.55280	2023.2	325733
645	416025	268336125	25.3969	8.6401	2.80956	1.55039	2026.3	326745
646	417316	269586136	25.4165	8.6446	2.81023	1.54799	2029.5	327759
647	418609	270840023	25.4362	8.6490	2.81090	1.54560	2032.6	328775
648	419904	272097792	25.4558	8.6535	2.81158	1.54321	2035.8	329792
649	421201	273359449	25.4755	8.6579	2.81224	1.54083	2038.9	330810

FUNCTIONS OF NUMBERS

650

699

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter	
							Circum.	Area
650	422500	274625000	25.4951	8.6624	2.81291	1.53846	2042.0	331831
651	423801	275894451	25.5147	8.6668	2.81358	1.53610	2045.2	332853
652	425104	277167808	25.5343	8.6713	2.81425	1.53374	2048.3	333876
653	426409	278445077	25.5539	8.6757	2.81491	1.53139	2051.5	334901
654	427716	279726264	25.5734	8.6801	2.81558	1.52905	2054.6	335927
655	429025	281011375	25.5930	8.6845	2.81624	1.52672	2057.7	336955
656	430336	282300416	25.6125	8.6890	2.81690	1.52439	2060.9	337985
657	431649	283593393	25.6320	8.6934	2.81757	1.52207	2064.0	339016
658	432964	284890312	25.6515	8.6978	2.81823	1.51976	2067.2	340049
659	434281	286191179	25.6710	8.7022	2.81889	1.51745	2070.3	341084
660	435600	287496000	25.6905	8.7066	2.81954	1.51515	2073.5	342119
661	436921	288804781	25.7099	8.7110	2.82020	1.51286	2076.6	343157
662	438244	290117528	25.7294	8.7154	2.82086	1.51057	2079.7	344196
663	439569	291434247	25.7488	8.7198	2.82151	1.50830	2082.9	345237
664	440896	292754944	25.7682	8.7241	2.82217	1.50602	2086.0	346279
665	442225	294079625	25.7876	8.7285	2.82282	1.50376	2089.2	347323
666	443556	295408296	25.8070	8.7329	2.82347	1.50150	2092.3	348368
667	444889	296740963	25.8263	8.7373	2.82413	1.49925	2095.4	349415
668	446224	298077632	25.8457	8.7416	2.82478	1.49701	2098.6	350464
669	447561	299418309	25.8650	8.7460	2.82543	1.49477	2101.7	351514
670	448900	300763000	25.8844	8.7503	2.82607	1.49254	2104.9	352565
671	450241	302111711	25.9037	8.7547	2.82672	1.49031	2108.0	353618
672	451584	303464448	25.9230	8.7590	2.82737	1.48810	2111.2	354673
673	452929	304821217	25.9422	8.7634	2.82082	1.48588	2114.3	355730
674	454276	306182024	25.9615	8.7677	2.82866	1.48368	2117.4	356788
675	455625	307546875	25.9808	8.7721	2.82930	1.48148	2120.6	357847
676	456976	308915776	26.0000	8.7764	2.82995	1.47929	2123.7	358908
677	458329	310288733	26.0192	8.7807	2.83059	1.47710	2126.9	359971
678	459684	311665752	26.0384	8.7850	2.83123	1.47493	2130.0	361035
679	461041	313046839	26.0576	8.7893	2.83187	1.47275	2133.1	362101
680	462400	314432000	26.0768	8.7937	2.83251	1.47059	2136.3	363168
681	463761	315821241	26.0960	8.7980	2.83315	1.46843	2139.4	364237
682	465124	317214568	26.1151	8.8023	2.83378	1.46623	2142.6	365308
683	466489	318611987	26.1343	8.8066	2.83442	1.46413	2145.7	366380
684	467856	320013504	26.1534	8.8109	2.83506	1.46199	2148.8	367453
685	469225	321419125	26.1725	8.8152	2.83569	1.45985	2152.0	368528
686	470596	322828856	26.1916	8.8194	2.83632	1.45773	2155.1	369605
687	471969	324242703	26.2107	8.8237	2.83696	1.45560	2158.3	370684
688	473344	325660672	26.2298	8.8280	2.83759	1.45349	2161.4	371764
689	474721	327082769	26.2488	8.8323	2.83822	1.45138	2164.6	372845
690	476100	328509000	26.2679	8.8366	2.83885	1.44928	2167.7	373928
691	477481	329939371	26.2869	8.8408	2.83948	1.44718	2170.8	375013
692	478864	331373888	26.3059	8.8451	2.84011	1.44509	2174.0	376099
693	480249	332812557	26.3249	8.8493	2.84073	1.44300	2177.1	377187
694	481636	334255384	26.3439	8.8536	2.84136	1.44092	2180.3	378276
695	483025	335702375	26.3629	8.8578	2.84198	1.43885	2183.4	379367
696	484416	337153536	26.3818	8.8621	2.84261	1.43678	2186.5	380459
697	485809	338608873	26.4008	8.8663	2.84323	1.43472	2189.7	381553
698	487204	340068392	26.4197	8.8706	2.84386	1.43266	2192.8	382649
699	488601	341532099	26.4386	8.8748	2.84448	1.43062	2196.0	383746

700
749

FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter	
							Circum.	Area
700	490000	343000000	26.4575	8.8790	2.84510	1.42857	2199.1	384845
701	491401	344472101	26.4764	8.8833	2.84572	1.42653	2202.3	385945
702	492804	345948408	26.4953	8.8875	2.84634	1.42450	2205.4	387047
703	494209	347428927	26.5141	8.8917	2.84696	1.42248	2208.5	388151
704	495616	348913664	26.5330	8.8959	2.84757	1.42045	2211.7	389256
705	497025	350402625	26.5518	8.9001	2.84819	1.41844	2214.8	390363
706	498436	351895816	26.5707	8.9043	2.84880	1.41643	2218.0	391471
707	499849	353393243	26.5895	8.9085	2.84942	1.41443	2221.1	392580
708	501264	354894912	26.6083	8.9127	2.85003	1.41243	2224.2	393692
709	502681	356400829	26.6271	8.9169	2.85065	1.41044	2227.4	394805
710	504100	357911000	26.6458	8.9211	2.85126	1.40845	2230.5	395919
711	505521	359425431	26.6646	8.9253	2.85187	1.40647	2233.7	397035
712	506944	360944128	26.6833	8.9295	2.85248	1.40449	2236.8	398153
713	508369	362467097	26.7021	8.9337	2.85309	1.40252	2240.0	399272
714	509796	363994344	26.7208	8.9378	2.85370	1.40056	2243.1	400393
715	511225	365525875	26.7395	8.9420	2.85431	1.39860	2246.2	401515
716	512656	367061696	26.7582	8.9462	2.85491	1.39665	2249.4	402639
717	514089	368601813	26.7769	8.9503	2.85552	1.39470	2252.5	403765
718	515524	370146232	26.7955	8.9545	2.85612	1.39276	2255.7	404892
719	516961	371694959	26.8142	8.9587	2.85673	1.39082	2258.8	406020
720	518400	373248000	26.8328	8.9628	2.85733	1.38889	2261.9	407150
721	519841	374805361	26.8514	8.9670	2.85794	1.38696	2265.1	408282
722	521284	376367048	26.8701	8.9711	2.85854	1.38504	2268.2	409415
723	522729	377933067	26.8887	8.9752	2.85914	1.38313	2271.4	410550
724	524176	379503424	26.9072	8.9794	2.85974	1.38122	2274.5	411687
725	525625	381078125	26.9258	8.9835	2.86034	1.37931	2277.7	412825
726	527076	382657176	26.9444	8.9876	2.86094	1.37741	2280.8	413965
727	528529	384240583	26.9629	8.9918	2.86153	1.37552	2283.9	415106
728	529984	385828352	26.9815	8.9959	2.86213	1.37363	2287.1	416248
729	531441	387420489	27.0000	9.0000	2.86273	1.37174	2290.2	417393
730	532900	389017000	27.0185	9.0041	2.86332	1.36986	2293.4	418539
731	534361	390617891	27.0370	9.0082	2.86392	1.36799	2296.5	419686
732	535824	392223168	27.0555	9.0123	2.86451	1.36612	2299.6	420835
733	537289	393832837	27.0740	9.0164	2.86510	1.36426	2302.8	421986
734	538756	395446904	27.0924	9.0205	2.86570	1.36240	2305.9	423138
735	540225	397065375	27.1109	9.0246	2.86629	1.36054	2309.1	424293
736	541696	398688256	27.1293	9.0287	2.86688	1.35870	2312.2	425447
737	543169	400315553	27.1477	9.0328	2.86747	1.35685	2315.4	426604
738	544644	401947272	27.1662	9.0369	2.86806	1.35501	2318.5	427762
739	546121	403583419	27.1846	9.0410	2.86864	1.35318	2321.6	428922
740	547600	405224000	27.2029	9.0450	2.86923	1.35135	2324.8	430084
741	549081	406869021	27.2213	9.0491	2.86982	1.34953	2327.9	431247
742	550564	408518488	27.2397	9.0532	2.87040	1.34771	2331.1	432412
743	552049	410172407	27.2580	9.0572	2.87099	1.34590	2334.2	433578
744	553536	411830784	27.2764	9.0613	2.87157	1.34409	2337.3	434746
745	555025	413493625	27.2947	9.0654	2.87216	1.34228	2340.5	435916
746	556516	415160936	27.3130	9.0694	2.87274	1.34048	2343.6	437087
747	558009	416832723	27.3313	9.0735	2.87332	1.33869	2346.8	438259
748	559504	418508992	27.3496	9.0775	2.87390	1.33690	2349.9	439433
749	561001	420189749	27.3679	9.0816	2.87448	1.33511	2353.1	440609

FUNCTIONS OF NUMBERS

750

799

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter	
							Circum.	Area
750	562500	421875000	27.3861	9.0856	2.87506	1.33333	2356.2	441786
751	564001	423564751	27.4044	9.0896	2.87564	1.33156	2359.3	442965
752	565504	425259008	27.4226	9.0937	2.87622	1.32979	2362.5	444146
753	567009	426957777	27.4408	9.0977	2.87680	1.32802	2365.6	445328
754	568516	428661064	27.4591	9.1017	2.87737	1.32626	2368.8	446511
755	570025	430368875	27.4773	9.1057	2.87795	1.32450	2371.9	447697
756	571536	432081216	27.4955	9.1098	2.87852	1.32275	2375.0	448883
757	573049	433798093	27.5136	9.1138	2.87910	1.32100	2378.2	450072
758	574564	435519512	27.5318	9.1178	2.87967	1.31926	2381.3	451262
759	576081	437245479	27.5500	9.1218	2.88024	1.31752	2384.5	452453
760	577600	438976000	27.5681	9.1258	2.88081	1.31579	2387.6	453646
761	579121	440711081	27.5862	9.1298	2.88138	1.31406	2390.8	454841
762	580644	442450728	27.6043	9.1338	2.88196	1.31234	2393.9	456037
763	582169	444194947	27.6225	9.1378	2.88252	1.31062	2397.0	457234
764	583696	445943744	27.6405	9.1418	2.88309	1.30890	2400.2	458434
765	585225	447697125	27.6586	9.1458	2.88366	1.30719	2403.3	459635
766	586756	449455096	27.6767	9.1498	2.88423	1.30548	2406.5	460837
767	588289	451217663	27.6948	9.1537	2.88480	1.30378	2409.6	462041
768	589824	452984832	27.7128	9.1577	2.88536	1.30208	2412.7	463247
769	591361	454756609	27.7308	9.1617	2.88593	1.30039	2415.9	464454
770	592900	456533000	27.7489	9.1657	2.88649	1.29870	2419.0	465663
771	594441	458314011	27.7669	9.1696	2.88705	1.29702	2422.2	466873
772	595984	460099648	27.7849	9.1736	2.88762	1.29534	2425.3	468085
773	597529	461889917	27.8029	9.1775	2.88818	1.29366	2428.5	469298
774	599076	463684824	27.8209	9.1815	2.88874	1.29199	2431.6	470513
775	600625	465484375	27.8388	9.1855	2.88930	1.29032	2434.7	471730
776	602176	467288576	27.8568	9.1894	2.88986	1.28866	2437.9	472948
777	603729	469097433	27.8747	9.1933	2.89042	1.28700	2441.0	474168
778	605284	470910952	27.8927	9.1973	2.89098	1.28535	2444.2	475389
779	606841	472729139	27.9106	9.2012	2.89154	1.28370	2447.3	476612
780	608400	474552000	27.9285	9.2052	2.89209	1.28205	2450.4	477836
781	609961	476379541	27.9464	9.2091	2.89265	1.28041	2453.6	479062
782	611524	478211768	27.9643	9.2130	2.89321	1.27877	2456.7	480290
783	613089	480048687	27.9821	9.2170	2.89376	1.27714	2459.9	481519
784	614656	481890304	28.0000	9.2209	2.89432	1.27551	2463.0	482750
785	616225	483736625	28.0179	9.2248	2.89487	1.27389	2466.2	483982
786	617796	485587656	28.0357	9.2287	2.89542	1.27226	2469.3	485216
787	619369	487443403	28.0535	9.2326	2.89597	1.27065	2472.4	486451
788	620944	489303872	28.0713	9.2365	2.89653	1.26904	2475.6	487688
789	622521	491169069	28.0891	9.2404	2.89708	1.26743	2478.7	488927
790	624100	493039000	28.1069	9.2443	2.89763	1.26582	2481.9	490167
791	625681	494913671	28.1247	9.2482	2.89818	1.26422	2485.0	491409
792	627264	496793088	28.1425	9.2521	2.89873	1.26263	2488.1	492652
793	628849	498677257	28.1603	9.2560	2.89927	1.26103	2491.3	493897
794	630436	500566184	28.1780	9.2599	2.89982	1.25945	2494.4	495143
795	632025	502459875	28.1957	9.2638	2.90037	1.25786	2497.6	496391
796	633616	504358336	28.2135	9.2677	2.90091	1.25628	2500.7	497641
797	635209	506261573	28.2312	9.2716	2.90146	1.25471	2503.8	498892
798	636804	508169592	28.2489	9.2754	2.90200	1.25313	2507.0	500145
799	638401	510082399	28.2666	9.2793	2.90255	1.25156	2510.1	501399

800

849

FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter	
							Circum.	Area
800	640000	512000000	28.2843	9.2832	2.90309	1.25000	2513.3	502655
801	641601	513922401	28.3019	9.2870	2.90363	1.24844	2516.4	503912
802	643204	515849608	28.3196	9.2909	2.90417	1.24688	2519.6	505171
803	644809	517781627	28.3373	9.2948	2.90472	1.24533	2522.7	506432
804	646416	519718464	28.3549	9.2986	2.90526	1.24378	2525.8	507694
805	648025	521660125	28.3725	9.3025	2.90580	1.24224	2529.0	508958
806	649636	523606616	28.3901	9.3063	2.90634	1.24069	2532.1	510223
807	651249	525557943	28.4077	9.3102	2.90687	1.23916	2535.3	411490
808	652864	527514112	28.4253	9.3140	2.90741	1.23762	2538.4	512758
809	654481	529475129	28.4429	9.3179	2.90795	1.23609	2541.5	514028
810	656100	531441000	28.4605	9.3217	2.90849	1.23457	2544.7	515300
811	657721	533411731	28.4781	9.3255	2.90902	1.23305	2547.8	516573
812	659344	535387328	28.4956	9.3294	2.90956	1.23153	2551.0	517848
813	660969	537367797	28.5132	9.3332	2.91009	1.23001	2554.1	519124
814	662596	539353144	28.5307	9.3370	2.91062	1.22850	2557.3	520402
815	664225	541343375	28.5482	9.3408	2.91116	1.22699	2560.4	521681
816	665856	543338496	28.5657	9.3447	2.91169	1.22549	2563.5	522962
817	667489	545338513	28.5832	9.3485	2.91222	1.22399	2566.7	524245
818	669124	547343432	28.6007	9.3523	2.91275	1.22249	2569.8	525529
819	670761	549353259	28.6182	9.3561	2.91328	1.22100	2573.0	526814
820	672400	551368000	28.6356	9.3599	2.91381	1.21951	2576.1	528102
821	674041	553387661	28.6531	9.3637	2.91434	1.21803	2579.2	529391
822	675684	555412248	28.6705	9.3675	2.91487	1.21655	2582.4	530681
823	677329	557441767	28.6880	9.3713	2.91540	1.21507	2585.5	531973
824	678976	559476224	28.7054	9.3751	2.91593	1.21359	2588.7	533267
825	680625	561515625	28.7228	9.3789	2.91645	1.21212	2591.8	534562
826	682276	563559976	28.7402	9.3827	2.91698	1.21065	2595.0	535858
827	683929	565609283	28.7576	9.3865	2.91751	1.20919	2598.1	537157
828	685584	567663552	28.7750	9.3902	2.91803	1.20773	2601.2	538456
829	687241	569722789	28.7924	9.3940	2.91855	1.20627	2604.4	539758
830	688900	571787000	28.8097	9.3978	2.91908	1.20482	2607.5	541061
831	690561	573856191	28.8271	9.4016	2.91960	1.20337	2610.7	542365
832	692224	575930368	28.8444	9.4053	2.92012	1.20192	2613.8	543671
833	693889	578009537	28.8617	9.4091	2.92065	1.20048	2616.9	544979
834	695556	580093704	28.8791	9.4129	2.92117	1.19904	2620.1	546288
835	697225	582182875	28.8964	9.4166	2.92169	1.19760	2623.2	547599
836	698896	584277056	28.9137	9.4204	2.92221	1.19617	2626.4	548912
837	700569	586376253	28.9310	9.4241	2.92273	1.19474	2629.5	550226
838	702244	588480472	28.9482	9.4279	2.92324	1.19332	2632.7	551541
839	703921	590589719	28.9655	9.4316	2.92376	1.19190	2635.8	552858
840	705600	592704000	28.9828	9.4354	2.92428	1.19048	2638.9	554177
841	707281	594823321	29.0000	9.4391	2.92480	1.18906	2642.1	555497
842	708964	596947688	29.0172	9.4429	2.92531	1.18765	2645.2	556819
843	710649	599077107	29.0345	9.4466	2.92583	1.18624	2648.4	558142
844	712336	601211584	29.0517	9.4503	2.92634	1.18483	2651.5	559467
845	714025	603351125	29.0689	9.4541	2.92686	1.18343	2654.6	560794
846	715716	605495736	29.0861	9.4578	2.92737	1.18203	2657.8	562122
847	717409	607645423	29.1033	9.4615	2.92788	1.18064	2660.9	563452
848	719104	609800192	29.1204	9.4652	2.92840	1.17925	2664.1	564783
849	720801	611960049	29.1376	9.4690	2.92891	1.17786	2667.2	566116

FUNCTIONS OF NUMBERS

850

899

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter	
							Circum.	Area
850	722500	614125000	29.1548	9.4727	2.92942	1.17647	2670.4	567450
851	724201	616295051	29.1719	9.4764	2.92993	1.17509	2673.5	568786
852	725904	618470208	29.1890	9.4801	2.93044	1.17371	2676.6	570124
853	727609	620650477	29.2062	9.4838	2.93095	1.17233	2679.8	571463
854	729316	622835864	29.2233	9.4875	2.93146	1.17096	2682.9	572803
855	731025	625026375	29.2404	9.4912	2.93197	1.16959	2686.1	574146
856	732736	627222016	29.2575	9.4949	2.93247	1.16822	2689.2	575490
857	734449	629422793	29.2746	9.4986	2.93298	1.16686	2692.3	576835
858	736164	631628712	29.2916	9.5023	2.93349	1.16550	2695.5	578182
859	737881	633839779	29.3087	9.5060	2.93399	1.16414	2698.6	579530
860	739600	636056000	29.3258	9.5097	2.93450	1.16279	2701.8	580880
861	741321	638277381	29.3428	9.5134	2.93500	1.16144	2704.9	582232
862	743044	640503928	29.3598	9.5171	2.93551	1.16009	2708.1	583585
863	744769	642735647	29.3769	9.5207	2.93601	1.15875	2711.2	584940
864	746496	644972544	29.3939	9.5244	2.93651	1.15741	2714.3	586297
865	748225	647214625	29.4109	9.5281	2.93702	1.15607	2717.5	587655
866	749956	649461896	29.4279	9.5317	2.93752	1.15473	2720.6	589014
867	751689	651714363	29.4449	9.5354	2.93802	1.15340	2723.8	590375
868	753424	653972032	29.4618	9.5391	2.93852	1.15207	2726.9	591738
869	755161	656234909	29.4788	9.5427	2.93902	1.15075	2730.0	593102
870	756900	658503000	29.4958	9.5464	2.93952	1.14943	2733.2	594468
871	758641	660776311	29.5127	9.5501	2.94002	1.14811	2736.3	595835
872	760384	663054848	29.5296	9.5537	2.94052	1.14679	2739.5	597204
873	762129	665338617	29.5466	9.5574	2.94101	1.14548	2742.6	598575
874	763876	667627624	29.5635	9.5610	2.94151	1.14416	2745.8	599947
875	765625	669921875	29.5804	9.5647	2.94201	1.14286	2748.9	601320
876	767376	672221376	29.5973	9.5683	2.94250	1.14155	2752.0	602696
877	769129	674526133	29.6142	9.5719	2.94300	1.14025	2755.2	604073
878	770884	676836152	29.6311	9.5756	2.94349	1.13895	2758.3	605451
879	772641	679151439	29.6479	9.5792	2.94399	1.13766	2761.5	606831
880	774400	681472000	29.6648	9.5828	2.94448	1.13636	2764.6	608212
881	776161	683797841	29.6816	9.5865	2.94498	1.13507	2767.7	609595
882	777924	686128968	29.6985	9.5901	2.94547	1.13379	2770.9	610980
883	779689	688465387	29.7153	9.5937	2.94596	1.13250	2774.0	612366
884	781456	690807104	29.7321	9.5973	2.94645	1.13122	2777.2	613754
885	783225	693154125	29.7489	9.6010	2.94694	1.12994	2780.3	615143
886	784996	695506456	29.7658	9.6046	2.94743	1.12867	2783.5	616534
887	786769	697864103	29.7825	9.6082	2.94792	1.12740	2786.6	617927
888	788544	700227072	29.7993	9.6118	2.94841	1.12613	2789.7	619321
889	790321	702595369	29.8161	9.6154	2.94890	1.12486	2792.9	620717
890	792100	704969000	29.8329	9.6190	2.94939	1.12360	2796.0	622114
891	793881	707347971	29.8496	9.6226	2.94988	1.12233	2799.2	623513
892	795664	709732288	29.8664	9.6262	2.95036	1.12108	2802.3	624913
893	797449	712121957	29.8831	9.6298	2.95085	1.11982	2805.4	626315
894	799236	714516984	29.8998	9.6334	2.95134	1.11857	2808.6	627718
895	801025	716917375	29.9166	9.6370	2.95182	1.11732	2811.7	629124
896	802816	719323136	29.9333	9.6406	2.95231	1.11607	2814.9	630530
897	804609	721734273	29.9500	9.6442	2.95279	1.11483	2818.0	631938
898	806404	724150792	29.9666	9.6477	2.95328	1.11359	2821.2	633348
899	808201	726572699	29.9833	9.6513	2.95376	1.11235	2824.3	634760

900

949

FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter	
							Circum.	Area
900	810000	729000000	30.0000	9.6549	2.95424	1.11111	2827.4	636173
901	811801	731432701	30.0167	9.6585	2.95472	1.10988	2830.6	637587
902	813604	733870808	30.0333	9.6620	2.95521	1.10865	2833.7	639003
903	815409	736314327	30.0500	9.6656	2.95569	1.10742	2836.9	640421
904	817216	738763264	30.0666	9.6692	2.95617	1.10619	2840.0	641840
905	819025	741217625	30.0832	9.6727	2.95665	1.10497	2843.1	643261
906	820836	743677416	30.0998	9.6763	2.95713	1.10375	2846.3	644683
907	822649	746142643	30.1164	9.6799	2.95761	1.10254	2849.4	646107
908	824464	748613312	30.1330	9.6834	2.95809	1.10132	2852.6	647533
909	826281	751089429	30.1496	9.6870	2.95856	1.10011	2855.7	648960
910	828100	753571000	30.1662	9.6905	2.95904	1.09890	2858.8	650388
911	829921	756058031	30.1828	9.6941	2.95952	1.09769	2862.0	651818
912	831744	758550528	30.1993	9.6976	2.95999	1.09649	2865.1	653250
913	833569	761048497	30.2159	9.7012	2.96047	1.09529	2868.3	654684
914	835396	763551944	30.2324	9.7047	2.96095	1.09409	2871.4	656118
915	837225	766060875	30.2490	9.7082	2.96142	1.09290	2874.6	657555
916	839056	768575296	30.2655	9.7118	2.96190	1.09170	2877.7	658993
917	840889	771095213	30.2820	9.7153	2.96237	1.09051	2880.8	660433
918	842724	773620632	30.2985	9.7188	2.96284	1.08932	2884.0	661874
919	844561	776151559	30.3150	9.7224	2.96332	1.08814	2887.1	663317
920	846400	778688000	30.3315	9.7259	2.96379	1.08696	2890.3	664761
921	848241	781229961	30.3480	9.7294	2.96426	1.08578	2893.4	666207
922	850084	783777448	30.3645	9.7329	2.96473	1.08460	2896.5	667654
923	851929	786330467	30.3809	9.7364	2.96520	1.08342	2899.7	669103
924	853776	788889024	30.3974	9.7400	2.96567	1.08225	2902.8	670554
925	855625	791453125	30.4138	9.7435	2.96614	1.08108	2906.0	672006
926	857476	794022776	30.4302	9.7470	2.96661	1.07991	2909.1	673460
927	859329	796597983	30.4467	9.7505	2.96708	1.07875	2912.3	674915
928	861184	799178752	30.4631	9.7540	2.96755	1.07759	2915.4	676372
929	863041	801765089	30.4795	9.7575	2.96802	1.07643	2918.5	677831
930	864900	804357000	30.4959	9.7610	2.96848	1.07527	2921.7	679291
931	866761	806954491	30.5123	9.7645	2.96895	1.07411	2924.8	680752
932	868624	809557568	30.5287	9.7680	2.96942	1.07296	2928.0	682216
933	870489	812166237	30.5450	9.7715	2.96988	1.07181	2931.1	683680
934	872356	814780504	30.5614	9.7750	2.97035	1.07066	2934.2	685147
935	874225	817400375	30.5778	9.7785	2.97081	1.06952	2937.4	686615
936	876096	820025856	30.5941	9.7819	2.97128	1.06838	2940.5	688084
937	877969	822656953	30.6105	9.7854	2.97174	1.06724	2943.7	689555
938	879844	825293672	30.6268	9.7889	2.97220	1.06610	2946.8	691028
939	881721	827936019	30.6431	9.7924	2.97267	1.06496	2950.0	692502
940	883600	830584000	30.6594	9.7959	2.97313	1.06383	2953.1	693978
941	885481	833237621	30.6757	9.7993	2.97359	1.06270	2956.2	695455
942	887364	835896888	30.6920	9.8028	2.97405	1.06157	2959.4	696934
943	889249	838561807	30.7083	9.8063	2.97451	1.06045	2962.5	698415
944	891136	841232384	30.7246	9.8097	2.97497	1.05932	2965.7	699897
945	893025	843908625	30.7409	9.8132	2.97543	1.05820	2968.8	701380
946	894916	846590536	30.7571	9.8167	2.97589	1.05708	2971.9	702865
947	896809	849278123	30.7734	9.8201	2.97635	1.05597	2975.1	704352
948	898704	851971392	30.7896	9.8236	2.97681	1.05485	2978.2	705840
949	900601	854670349	30.8058	9.8270	2.97727	1.05374	2981.4	707330

FUNCTIONS OF NUMBERS

950

999

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter	
							Circum.	Area
950	902500	857375000	30.8221	9.8305	2.97772	1.05263	2984.5	708822
951	904401	860085351	30.8383	9.8339	2.97818	1.05152	2987.7	710315
952	906304	862801408	30.8545	9.8374	2.97864	1.05042	2990.8	711809
953	908209	865523177	30.8707	9.8408	2.97909	1.04932	2993.9	713306
954	910116	868250664	30.8869	9.8443	2.97955	1.04822	2997.1	714803
955	912025	870983875	30.9031	9.8477	2.98000	1.04712	3000.2	716303
956	913936	873722816	30.9192	9.8511	2.98046	1.04603	3003.4	717804
957	915849	876467493	30.9354	9.8546	2.98091	1.04493	3006.5	719306
958	917764	879217912	30.9516	9.8580	2.98137	1.04384	3009.6	720810
959	919681	881974079	30.9677	9.8614	2.98182	1.04275	3012.8	722316
960	921600	884736000	30.9839	9.8648	2.98227	1.04167	3015.9	723823
961	923521	887503681	31.0000	9.8683	2.98272	1.04058	3019.1	725332
962	925444	890277128	31.0161	9.8717	2.98318	1.03950	3022.2	726842
963	927369	893056347	31.0322	9.8751	2.98363	1.03842	3025.4	728354
964	929296	895841344	31.0483	9.8785	2.98408	1.03734	3028.5	729867
965	931225	898632125	31.0644	9.8819	2.98453	1.03627	3031.6	731382
966	933156	901428696	31.0805	9.8854	2.98498	1.03520	3034.8	732899
967	935089	904231063	31.0966	9.8888	2.98543	1.03413	3037.9	734417
968	937024	907039232	31.1127	9.8922	2.98588	1.03306	3041.1	735937
969	938961	909853209	31.1288	9.8956	2.98632	1.03199	3044.2	737458
970	940900	912673000	31.1448	9.8990	2.98677	1.03093	3047.3	738981
971	942841	915498611	31.1609	9.9024	2.98722	1.02987	3050.5	740506
972	944784	918330048	31.1769	9.9058	2.98767	1.02881	3053.6	742032
973	946729	921167317	31.1929	9.9092	2.98811	1.02775	3056.8	743559
974	948676	924010424	31.2090	9.9126	2.98856	1.02669	3059.9	745088
975	950625	926859375	31.2250	9.9160	2.98900	1.02564	3063.1	746619
976	952576	929714176	31.2410	9.9194	2.98945	1.02459	3066.2	748151
977	954529	932574833	31.2570	9.9227	2.98989	1.02354	3069.3	749685
978	956484	935441352	31.2730	9.9261	2.99034	1.02249	3072.5	751221
979	958441	938313739	31.2890	9.9295	2.99078	1.02145	3075.6	752758
980	960400	941192000	31.3050	9.9329	2.99123	1.02041	3078.8	754296
981	962361	944076141	31.3209	9.9363	2.99167	1.01937	3081.9	755837
982	964324	946966168	31.3369	9.9396	2.99211	1.01833	3085.0	757378
983	966289	949862087	31.3528	9.9430	2.99255	1.01729	3088.2	758922
984	968256	952763904	31.3688	9.9464	2.99300	1.01626	3091.3	760466
985	970225	955671625	31.3847	9.9497	2.99344	1.01523	3094.5	762013
986	972196	958585256	31.4006	9.9531	2.99388	1.01420	3097.6	763561
987	974169	961504803	31.4166	9.9565	2.99432	1.01317	3100.8	765111
988	976144	964430272	31.4325	9.9598	2.99476	1.01215	3103.9	766662
989	978121	967361669	31.4484	9.9632	2.99520	1.01112	3107.0	768214
990	980100	970299000	31.4643	9.9666	2.99564	1.01010	3110.2	769769
991	982081	973242271	31.4802	9.9699	2.99607	1.00908	3113.3	771325
992	984064	976191488	31.4960	9.9733	2.99651	1.00806	3116.5	772882
993	986049	979146657	31.5119	9.9766	2.99695	1.00705	3119.6	774441
994	988036	982107784	31.5278	9.9800	2.99739	1.00604	3122.7	776002
995	990025	985074875	31.5436	9.9833	2.99782	1.00503	3125.9	777564
996	992016	988047936	31.5595	9.9866	2.99826	1.00402	3129.0	779128
997	994009	991026973	31.5753	9.9900	2.99870	1.00301	3132.2	780693
998	996004	994011992	31.5911	9.9933	2.99913	1.00200	3135.3	782260
999	998001	997002999	31.6070	9.9967	2.99957	1.00100	3138.5	783828

EQUIVALENTS OF MEASURE

LENGTHS

1 meter, m = 10 decimeters, dm = 100 centimeters, cm = 1000 millimeters, mm.
1 meter, m = 0.1 decameter, dkm = 0.01 hectometer, hm = 0.001 kilometer, km.
1 meter, m = 39.37 inches, U. S. Standard = 39.370113 inches, British Standard.
1 millimeter, mm = 1000 microns = 0.03937 inch = 39.37 mils.

Meters, m	Inches, in.	Feet, ft.	Yard, yd.	Rods, r.	Chains, ch.	MILES, U. S.		Kilometers, km.
						Statute	Nautical	
1	39.37	3.28083	1.09361	0.19884	0.04971	0.0006214	0.0005396	0.001
0.02540	1	0.08333	0.02778	0.005051	0.001263	0.00001578	0.00001371	0.00002540
0.30480	12	1	0.33333	0.06061	0.01515	0.0001894	0.0001645	0.0003048
0.91440	36	3	1	0.18182	0.04545	0.0005682	0.0004934	0.0009144
5.02921	198	16.5	5.5	1	0.25	0.003125	0.002714	0.005029
20.1168	792	66	22	4	1	0.01250	0.01085	0.02012
1609.35	63360	5280	1760	320	80	1	0.86839	1.60935
1853.25	72962.5	6080.20	2026.73	368.497	92.1243	1.15155	1	1.85325
1000	39370	3280.83	1093.61	198.838	49.7096	0.62137	0.53959	1

1 yard, U. S. = 1.0000029 yards British. 1 yard British = 0.9999971 yards U. S.
1 chain, Gunter's = 100 links 1 link = 7.92 inches.
1 cable length, U. S. = 120 fathoms = 960 spans = 720 feet = 219.457 meters.
1 league, U. S. = 3 statute miles = 24 furlongs.
1 international geographical mile = 1/15° at equator = 7422 m = 4.611808 U. S. statute miles.
1 international nautical mile = 1/60° at meridian = 1852 m = 0.999326 U. S. nautical miles.
1 U. S. nautical mile = 1/60° of circumference of sphere whose surface equals that of the earth = 6080.27 feet = 1.15155 statute miles = 1853.27 meters.
1 British nautical mile = 6080.00 feet = 1.15152 statute miles = 1853.19 meters.

VOLUME AND CAPACITY

1 cu. meter, m^3 = 1000 cu. decimeter, dm^3 = 1000000 cu. centimeters, cm^3.
1 liter, l = 10 deciliters, dl = 100 centiliters, cl = 1000 milliliters, ml = 1000 cu. centimeters, cm^3. or cc.
1 liter, l = 0.1 decaliter, dkl = 0.01 hectoliter, hl = 1 cu. decimeter, dm^3.

Cubic Decimeter dm3, l	Cubic Inches, cu. in.	Cubic Feet, cu. ft.	Cubic Yards, cu. yd.	U. S. QUARTS		U. S. GALLONS		U. S. Bushels, bu.
				Liquid, l. qt.	Dry, d. qt.	Liquid, l. gal.	Dry, d. gal.	
1	61.0234	0.03531	0.001308	1.05668	0.90808	0.26417	0.22702	0.02838
0.01639	1	0.0005787	0.00002143	0.01732	0.01488	0.004329	0.003720	0.0004650
28.3170	1728	1	0.03704	29.9221	25.7140	7.48055	6.42851	0.80356
764.559	46656	27	1	807.896	694.279	201.974	173.570	21.6962
0.94636	57.75	0.03342	0.001238	1	0.85937	0.25	0.21484	0.02686
1.10123	67.2006	0.03889	0.001440	1.16365	1	0.29091	0.25	0.03125
3.78543	231	0.13368	0.004951	4	3.43747	1	0.85937	0.10742
4.40492	268.803	0.15556	0.005761	4.65460	4	1.16365	1	0.125
35.2393	2150.42	1.24446	0.04609	37.2368	32	9.30920	8	1

U. S. Dry Measure: 1 bushel = 4 pecks = 8 gallons = 32 quarts = 64 pints.
U. S. Liquid Measure: 1 gallon = 4 quarts = 8 pints = 32 gills = 128 fluid ounces.
U. S. Apoth. Measure: 1 fl. ounce, f℥ = 8 fl. drams, f℥ = 480 minims = 29.574 cu. cm^3.
British Imperial gallon dry and liquid measure = 1.03202 U. S. dry gal. = 1.20091 U. S. liquid gallon.
British Imperial gallon = 277.410 cu. in. = 4545.9631 cm^3.
Weight of water at maximum density, 4°C, 45° Lat., and sea level.
1 cu. ft. = 62.4283 lbs. av. = 28.3170 kg. 1 cu. in. = 0.57804 oz. av. = 16.3872 g.
1 gal., U. S. liquid = 8.34545 lbs. = 3.78543 kg.
1 gal., British Imperial = 10.0221 lbs. = 4.5459631 kg.

MASSES AND WEIGHTS

1 gram, g = 10 decigrams, dg = 100 centigrams, cg = 1000 milligrams, mg.
1 gram, g = 0.1 decagram, dkg = 0.01 hectogram, hg = 0.001 kilogram, kg.
1 kilogram, kg = 1 cu. decimeter of water or liter, 4°C, 45° Lat. and sea level = 15432.35639 grains, U. S. and British Standard.

Kilograms, kg.	Grains, gr.	OUNCES		POUNDS		TONS		
		Troy, oz. t.	Avoir., oz. av.	Troy, lb. t.	Avoir., lb. av.	Net, Short, 2000 lbs.	Gross, Long, 2240 lbs.	Metric 1000 kg.
1	15432.4	32.1507	35.2740	2.67923	2.20462	0.001102	0.0009842	0.001
0.00006480	1	0.002083	0.002286	0.0001736	0.0001429	0.00000007143	0.00000006378	0.00000006480
0.03110	480	1	1.09714	0.08333	0.06857	0.00003429	0.00003061	0.00003110
0.02835	437.5	0.91146	1	0.07595	0.06250	0.00003125	0.00002790	0.00002835
0.37324	5760	12	13.1657	1	0.82286	0.0004114	0.0003674	0.0003732
0.45359	7000	14.5833	16	1.21528	1	0.00050	0.0004464	0.0004536
907.185	14000000	29166.7	32000	2430.56	2000	1	0.89286	0.90719
1016.05	15680000	32666.7	35840	2722.22	2240	1.12	1	1.01605
1000	15432356	32150.7	35274.0	2679.23	2204.62	1.10231	0.98421	1

1 ounce avoir. = 16 drams, avoir. 1 ounce troy = 20 pennyweight, dwt.
1 ounce apoth, ℥ = 8 drams, 3 = 24 scruples, ℈ = 480 grains, gr = 31.1035 g.
1 hundredweight = 1/20 long ton = 4 quarters = 8 stone = 112 lbs. = 50.8024 kg.

DECIMAL OF AN INCH AND OF A FOOT

Fractions of Inch or Foot		Inch Equivalents to Foot Fractions	Fractions of Inch or Foot		Inch Equivalents to Foot Fractions	Fractions of Inch or Foot		Inch Equivalents to Foot Fractions	Fractions of Inch or Foot		Inch Equivalents to Foot Fractions
	.0052	1/16		.2552	3 1/16		.5052	6 1/16		.7552	9 1/16
	.0104	⅛		.2604	3⅛		.5104	6⅛		.7604	9⅛
1/64	.015625	3/16	17/64	.265625	3 3/16	33/64	.515625	6 3/16	49/64	.765625	9 3/16
	.0208	¼		.2708	3¼		.5208	6¼		.7708	9¼
	.0260	5/16		.2760	3 5/16		.5260	6 5/16		.7760	9 5/16
1/32	.03125	⅜	9/32	.28125	3⅜	17/32	.53125	6⅜	25/32	.78125	9⅜
	.0365	7/16		.2865	3 7/16		.5365	6 7/16		.7865	9 7/16
	.0417	½		.2917	3½		.5417	6½		.7917	9½
3/64	.046875	9/16	19/64	.296875	3 9/16	35/64	.546875	6 9/16	51/64	.796875	9 9/16
	.0521	⅝		.3021	3⅝		.5521	6⅝		.8021	9⅝
	.0573	11/16		.3073	3 11/16		.5573	6 11/16		.8073	9 11/16
1/16	.0625	¾	5/16	.3125	3¾	9/16	.5625	6¾	13/16	.8125	9¾
	.0677	13/16		.3177	3 13/16		.5677	6 13/16		.8177	9 13/16
	.0729	⅞		.3229	3⅞		.5729	6⅞		.8229	9⅞
5/64	.078125	15/16	21/64	.328125	3 15/16	37/64	578125	6 15/16	53/64	.828125	9 15/16
	.0833	1		.3333	4		.5833	7		.8333	10
	.0885	1 1/16		.3385	4 1/16		.5885	7 1/16		.8385	10 1/16
3/32	.09375	1⅛	11/32	.34375	4⅛	19/32	.59375	7⅛	27/32	.84375	10⅛
	.0990	1 3/16		.3490	4 3/16		.5990	7 3/16		.8490	10 3/16
	.1042	1¼		.3542	4¼		.6042	7¼		.8542	10¼
7/64	.109375	1 5/16	23/64	.359375	4 5/16	39/64	.609375	7 5/16	55/64	.859375	10 5/16
	.1146	1⅜		.3646	4⅜		.6146	7⅜		.8646	10⅜
	.1198	1 7/16		.3698	4 7/16		.6198	7 7/16		.8698	10 7/16
1/8	.1250	1½	3/8	.3750	4½	5/8	.6250	7½	7/8	.8750	10½
	.1302	1 9/16		.3802	4 9/16		.6302	7 9/16		.8802	10 9/16
	.1354	1⅝		.3854	4⅝		.6354	7⅝		.8854	10⅝
9/64	.140625	1 11/16	25/64	.390625	4 11/16	41/64	.640625	7 11/16	57/64	.890625	10 11/16
	.1458	1¾		.3958	4¾		.6458	7¾		.8958	10¾
	.1510	1 13/16		.4010	4 13/16		.6510	7 13/16		.9010	10 13/16
5/32	.15625	1⅞	13/32	.40625	4⅞	21/32	.65625	7⅞	29/32	.90625	10⅞
	.1615	1 15/16		.4115	4 15/16		.6615	7 15/16		.9115	10 15/16
	.1667	2		.4167	5		.6667	8		.9167	11
11/64	.171875	2 1/16	27/64	.421875	5 1/16	43/64	.671875	8 1/16	59/64	.921875	11 1/16
	.1771	2⅛		.4271	5⅛		.6771	8⅛		.9271	11⅛
	.1823	2 3/16		.4323	5 3/16		.6823	8 3/16		.9323	11 3/16
3/16	.1875	2¼	7/16	.4375	5¼	11/16	.6875	8¼	15/16	.9375	11¼
	.1927	2 5/16		.4427	5 5/16		.6927	8 5/16		.9427	11 5/16
	.1979	2⅜		.4479	5⅜		.6979	8⅜		.9479	11⅜
13/64	.203125	2 7/16	29/64	.453125	5 7/16	45/64	.703125	8 7/16	61/64	.953125	11 7/16
	.2083	2½		.4583	5½		.7083	8½		.9583	11½
	.2135	2 9/16		.4635	5 9/16		.7135	8 9/16		.9635	11 9/16
7/32	.21875	2⅝	15/32	.46875	5⅝	23/32	.71875	8⅝	31/32	.96875	11⅝
	.2240	2 11/16		.4740	5 11/16		.7240	8 11/16		.9740	11 11/16
	.2292	2¾		.4792	5¾		.7292	8¾		.9792	11¾
15/64	.234375	2 13/16	31/64	.484375	5 13/16	47/64	.734375	8 13/16	63/64	.984375	11 13/16
	.2396	2⅞		.4896	5⅞		.7396	8⅞		.9896	11⅞
	.2448	2 15/16		.4948	5 15/16		.7448	8 15/16		.9948	11 15/16
1/4	.2500	3	1/2	.5000	6	3/4	.7500	9	1	1.0000	12

REINFORCING BARS

	SIZE BAR										
	¼φ	⅜φ	½φ	½□	⅝φ	¾φ	⅞φ	1φ	1□	1⅛□	1¼□
Area..........	.05	.11	.20	.25	.31	.44	.60	.79	1.00	1.27	1.56
Weight........	.17	.38	.68	.86	1.06	1.52	2.07	2.70	3.44	4.35	5.37
Perimeter......	.79	1.18	1.57	2.00	1.96	2.36	2.75	3.14	4.00	4.50	5.00

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Date Due

Due	Returned	Due	Returned
MAR 5 '79	FE 12 '79		
MAY 16 '79			
FEB 3 - 1983			
APR 2 7 1983			

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